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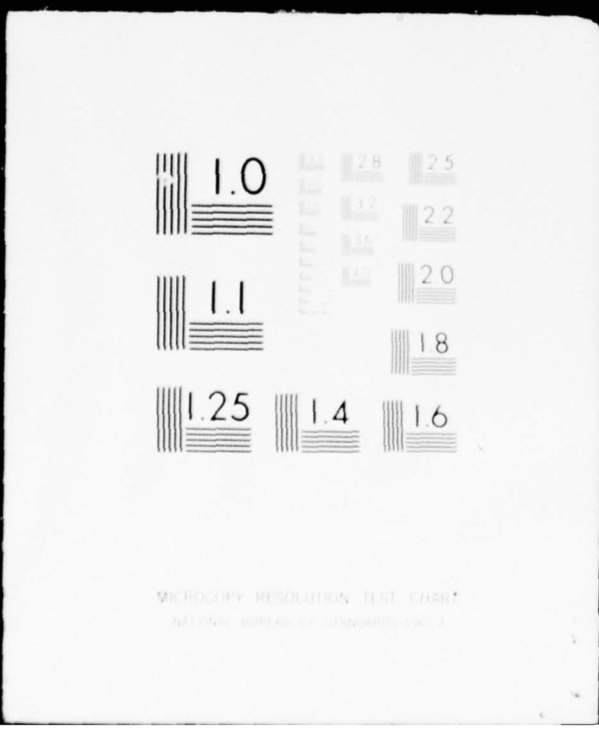
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MICROCOPY RESOLUTION TEST CHART
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Vol 7

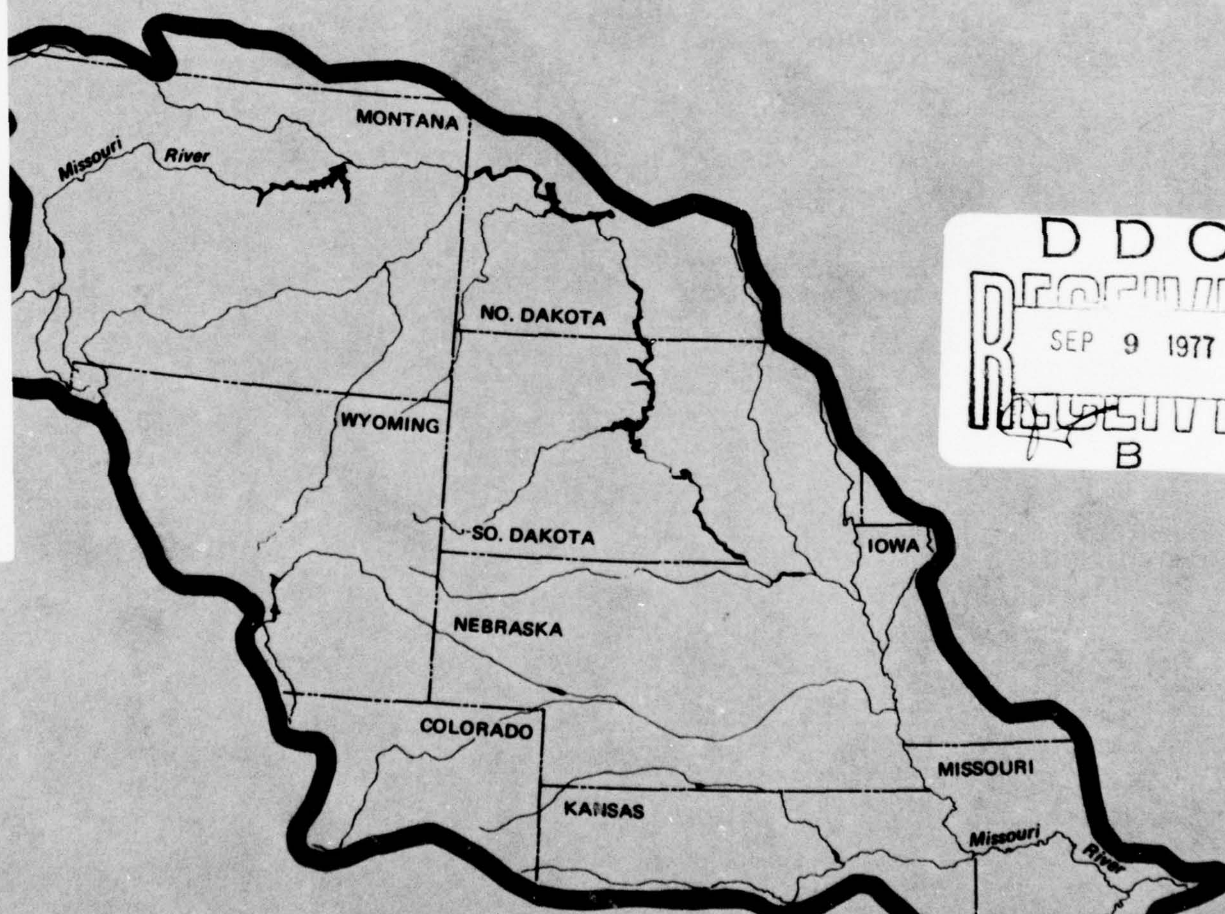
The Missouri River Basin

The Missouri River Basin Comprehensive Framework Study

• Plan of Development and Management

Volume 7

Appendix



Missouri Basin Inter-Agency Committee
Standing Committee
June 1969

Published December 1971

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MISSOURI RIVER BASIN.

VOLUME 7.

APPENDIX.

PLAN OF DEVELOPMENT AND MANAGEMENT OF
WATER AND RELATED LAND RESOURCES.

MISSOURI BASIN INTER-AGENCY COMMITTEE

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Published December 1971

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COMPREHENSIVE FRAMEWORK STUDY

MISSOURI RIVER BASIN

REPORT

Volume 1 – Comprehensive Framework Study

APPENDICES

Volume 2 – Historical Perspective of the Missouri River Basin

History of the Framework Study

Existing Water and Land Resources Development

Volume 3 – Laws, Policies, and Administration Related to Water Resources Development

Volume 4 – Economic Analysis and Projections

Volume 5 – Present and Future Needs

Volume 6 – Land Resources Availability

Hydrologic Analyses and Projections

*Volume 7 – Plan of Development and Management of Water and Related Land Resources

*Covered in this Volume

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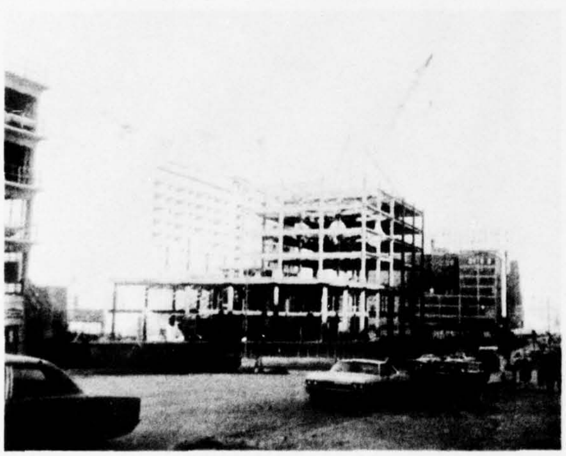
CHAPTER 1

INTRODUCTION

The countless problems that must be faced and resolved in the development and management of land and water resources have been enumerated many times over. These include the accelerating urban growth that places great demands on natural resources, the difficult choices that must be made in allocating limited public funds among competing, yet extensive, public services, the recurrent human and economic destruction caused by floods, the maldistribution or scarcity of water resources, the pollution of streams, and those special needs for development of natural resources in under-developed areas, or states. The citizen and every level of government have a vital role to play in solving these problems.

Recurring Floods Still Persist in the Basin



Accelerating Urban Growth Places Great Demands On Water And Land Resources

Recognizing the increasingly important responsibilities of Federal and State Governments in planning for the prudent use and conservation of natural resources for attaining a balanced and vigorous economy, the Missouri Basin Inter-Agency Committee agreed in 1963 to undertake a framework study of the basin. River basin framework planning is, in essence, regional planning. Such planning provides broad-scale analyses of water and related land resource problems and the means of determining the probable nature, extent, and timing of measures for their solution. The regional approach is not new to planners of the Missouri River Basin since the first comprehensive basin developmental program was incorporated in the comprehensive plan, commonly known as the Pick-Sloan Plan, approved by the Congress in 1944. The origin of that plan stemmed from a resolution adopted by the Missouri River States Committee requesting Federal executive and legislative action to secure a single coordinated plan for development of the Missouri River Basin. At that time there were those who favored as well as those who opposed the plan, but much of what was then proposed is now reality. Therefore, with the passage of over two decades, it is appropriate to reappraise those earlier plans and subsequent accomplishments, and to formulate a framework plan as a guide for future actions.

As planning is essentially an advisory function, effective programs are those that achieve acceptability as well as quality. The heart of the planning function is a unified framework of policy which gives direction to a wide array of actions. The most excellent, commendable plan, however, has only a museum piece value unless its objectives and policies are ingrained in the action

programs and can be translated into effective legislation as necessary. On the other hand, support of hastily prepared and ill-advised plans is undesirable and should be discouraged.

An effective framework planning program, therefore, requires the formulation of a regional plan predicated on sound facts and information, sensible and realistic projections of needs, and imaginative well-thought-out objectives and criteria. Under no circumstances should the plan be considered inflexible or unchangeable. Not only can this possibility be avoided by realistic objectives and criteria, but the plan should be continually reappraised and revised in the light of changing conditions. The formulation procedures also must insure that the legal and institutional environment in which the framework plan and policies must operate is well understood by and acceptable to the institutions responsible for implementing the planning programs.

This appendix presents an integration of the estimated demands for goods and services with the availability of natural resources shown by information found

Sixty Percent of the Basin's People Live in Urban Areas

The Basin Is Endowed With A Quality Environment

in other appendices. Also, an interpretation of the data and information from these sources has been made in order to resolve, insofar as practicable, differences in functional needs. Care has been taken to outline planning objectives together with related planning criteria as being fundamental to a clear understanding of the total social, economic, and physical developments required for the basin. In most instances, detail descriptions of the technical aspects of planning are not included herein, but attention is focused instead on a clear and concise portrayal of what can and should be done in the basin to meet the broader needs of the future.

PLANNING OBJECTIVES

Realistic planning objectives are those that satisfy human demands and needs. It is recognized also, that objectives should be flexible in order that changes which occur in the future can be accommodated within a broad framework for the development and management of available resources.

The overall objective was the formulation of a framework plan which would provide a broad guide to the best uses, or combination of uses, of water and related land resources to meet foreseeable short- and long-term needs. Underlying this overall objective, consideration was given to (1) the timely development and management of these resources as essential aids to the economic development and growth of the basin; (2) the preservation of resources, as appropriate, to insure that they will be available for their best use as needed; and (3) the well-being of all the people as the overriding determinant.

To provide a more definitive direction for plan formulation, a multi-objective approach was considered

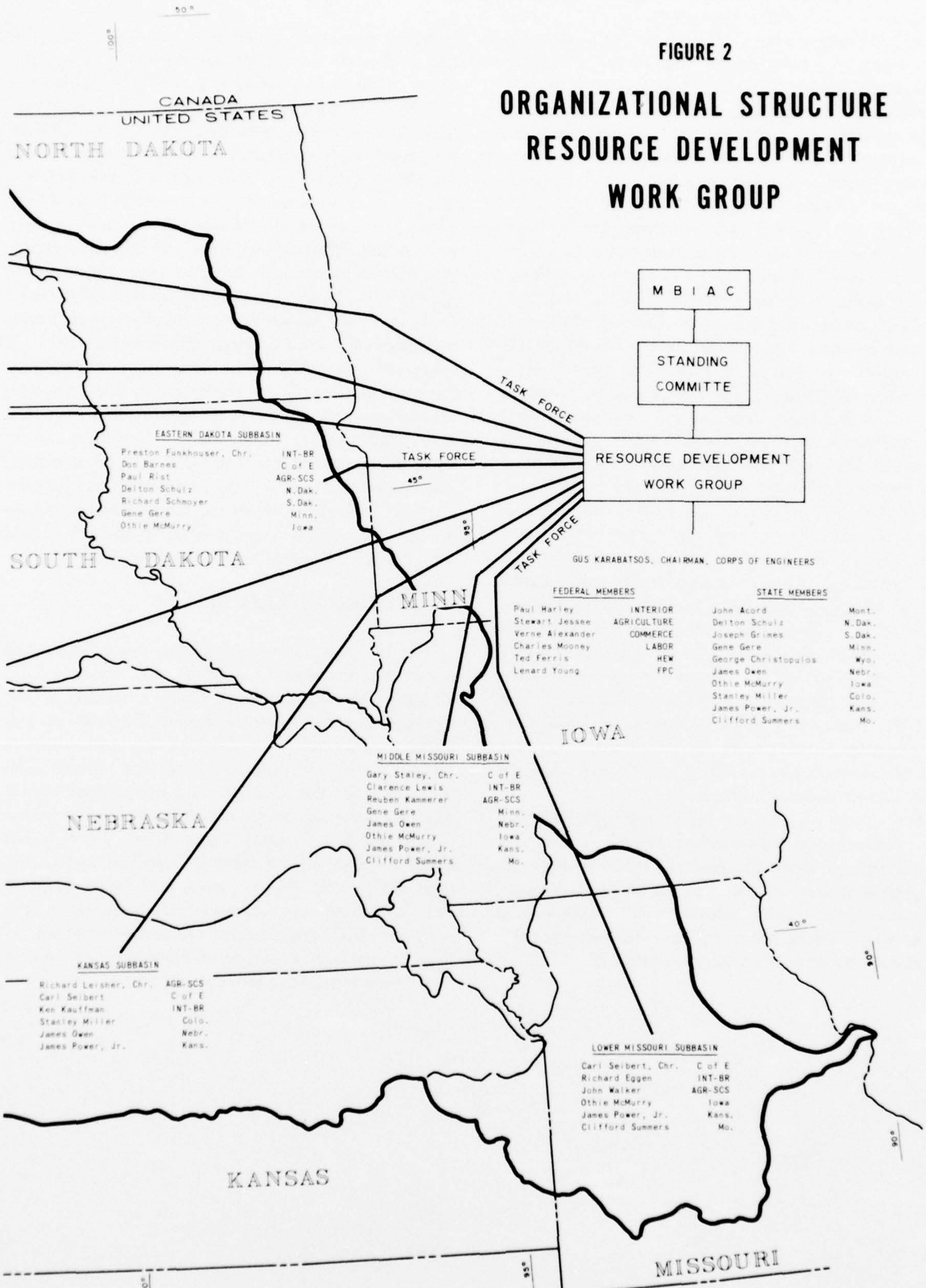
FIGURE 1

SUBBASIN BOUNDARIES


50°
110°
105°
115°
115°
45°
110°
40°
105°
UPPER MISSOURI SUBBASIN
Warren Weber, Chr. INT-BR
Gary Staley C of E
Robert Dean AGR-SCS
John Acord Mont.
Milo Hoisveen N.Dak.
MONTANA
YELLOWSTONE SUBBASIN
Robert Madsen, Chr. INT-BR
Wayne Stufft C of E
Robert Dean AGR-SCS
Keith Miller AGR-SCS
John Acord Mont.
Delton Schulz N.Dak.
George Christopulos Wyo.
WESTERN DAKOTA SUBBASIN
Robert Ferguson, Chr. AGR-SCS
Wayne Stufft C of E
Preston Funkhouser INT-BR
John Acord Mont.
Delton Schulz N.Dak.
Richard Schmoyer S.Dak.
George Christopulos Wyo.
James Owen Nebr.
WYOMING
N
PLATTE-NIOBRARA SUBBASIN
Reuben Kammerer, Chr. AGR-SCS
Wayne Stufft C of E
Clarence Lewis INT-BR
Ron Tangeman Wyo.
Stanley Miller Colo.
James Owen Nebr.
SCALE 1/6,400,000
50 0 50 100
APPROXIMATE SCALE IN MILES
CONSULTANTS AND PAST MEMBERS
Roy Schwamb C of E
Charles Burgtorf C of E
Cal Reedy INT-BR
Eugene Jarecki INT-BR
Emanuel Lauck INT-BOR
Frank Schiedorn AGR-SCS
Ray Huxtable AGR-SCS
Norm Hadenfeldt AGR-SCS
Kermit Irwin AGR-SCS
John Putman AGR-ERS
Aleck Alexander HEW
Eugene Schmidt INT-BLM
Walter Pool AGR-FS
Tom McNulty Mont.
Gene Krenz N.Dak.
Stan Wentz N.Dak.
James Schulz N.Dak.
William Walton Minn.
Ron Tangeman Wyo.
William Funk Iowa
William Lee Mo.
Lew Young INT-FWQA
Walt RuBohn INT-FWQA
Ken Schroeder INTERIOR
Garland Hershey Iowa
Wilfred Crabb INT-BSFW
COLORADO

FIGURE 2

ORGANIZATIONAL STRUCTURE RESOURCE DEVELOPMENT WORK GROUP



desirable. The fundamental reason for such an approach is that every water resource investment affects a variety of social objectives, even if designed to attain only one. Since many objectives can be affected by a resource development investment, the prudent course of action is to select those of most importance, and then determine which pattern of investments can best achieve some desired combination in the public interest.

Three general planning objectives were adopted. These are designated as: (1) national economic efficiency; (2) regional socio-economic development; and (3) preservation and enhancement of the quality of the environment. These objectives permit a comprehensive approach to the formulation of subbasin and basinwide investment patterns. The national objective is oriented primarily toward programs that would provide the greatest net return in goods and services on a national scale. Although this objective does provide a measure of well-being of people and an economic basis for investments, it is also a useful aid in assessing the extent of departure from this objective to meet other objectives that are in the regional and local interest.

For the regional objective, consideration was given in plan formulation toward achieving a regional pattern of desirable economic and social development. Within the third objective, it was recognized that environmental considerations are generally interwoven in all planning objectives. However, in order to assess significant environmental opportunities, especially those dealing with preservation and esthetic considerations, plan alternatives maximizing this objective were formulated. This approach makes it possible to assess the goods and services gained and foregone to achieve certain environmental objectives. More specific regional and subregional objectives are outlined in chapter 7.

The framework plan and significant and meaningful alternatives to the framework presented herein were formulated to meet the general objectives outlined. Judgments relative to the elements of the framework plan were made on the basis of options available and those which would produce a desirable and attainable combination to meet the objectives outlined.

STUDY AREAS

Water resources planning, of necessity, must be associated with manageable sources and uses of water supply, both surface and underground. For purposes of this study, the Missouri River basin has been divided into eight subbasins representing hydrologic areas drained by designated major tributaries or groups of tributaries of the Missouri River, and including certain closed basins. In addition, a terminal analysis was made to assess the probable effects on the Missouri River from development in the eight tributary areas, and thus to determine how the main stem water could be used to meet future requirements. Figure 1 shows the subbasin boundaries.

While water management must be associated with hydrologically defined areas, the planning effort is concerned also with socio-economic considerations. Socio-economic data are available only for politically defined counties and Standard Metropolitan Statistical Areas (SMSA's). Seldom do county boundaries conform to hydrologic boundaries. The basin or region, therefore, was divided also into subregions defined along political lines and following generally the subbasin boundaries. In general, the nomenclature of subbasin and subregional areas is, for all practical purposes, the same.

STUDY ORGANIZATION

The framework plan formulation was accomplished under the direction of a Water and Related Land Resource Development Work Group consisting of one representative each from the Federal Departments and States having overall coordination and policy responsibilities, and by eight planning task forces each responsible for the actual planning in a subbasin. Input data for their use were furnished by other echelons within the overall study organization. These inputs included data from an economic analyses and projections study, estimates of present and future demands and needs, hydrologic analyses, and inventories of land resources. The organizational structure is shown on figure 2 together with lists of individuals involved in preparation of the framework plan.

CHAPTER 2

DESCRIPTION OF THE BASIN

The basin contains one-sixth of the contiguous areas of the United States and includes all of Nebraska, most of Montana, North and South Dakota, and Wyoming, about half of Kansas and Missouri, smaller parts of Colorado, Iowa, and Minnesota, and some territory in Canada. Aside from international water accountability, the framework study was limited to that part of the basin within the United States.

The total area of the Missouri River Basin is about 529,300 square miles, of which 9,700 square miles are located in Canada. Of the total basin area of 519,600 square miles in the United States, 6,300 square miles are non-contributing drainage located along the basin's boundary. Formed by the junction of the Jefferson, Gallatin, and Madison Rivers at Three Forks, Mont., the Missouri River flows generally southeasterly 2,315 miles to its junction with the Mississippi River near St. Louis, Mo. The Yellowstone, Cheyenne, Niobrara, Platte, Kansas, Osage, and Gasconade Rivers, in downstream order, are the major tributary streams from the south and west, and the Milk, James, Big Sioux, Grand, and Chariton Rivers, from the north and east.

The Rocky Mountains Form the Basin's Western Boundary

PHYSICAL CHARACTERISTICS

Three major physical divisions and several lesser provinces characterize the basin, as shown on figure 3. The Rocky Mountain System forms the western boundary and reflects an exceptionally rugged topography, with many peaks surpassing 14,000 feet in elevation. The 55,000-square-mile mountainous area is punctuated with many high valleys, but the peaks and mountain spurs dominate the physical features.

Sloping eastward from the Rocky Mountains, the Great Plains, as the heartland of the basin and a province of the Interior Plains Division, encompass a broad belt of highlands which cover approximately 360,000 square miles. Their eastern boundary lies along the 1,500-foot contour, and the western boundary at the foot of the Rocky Mountains averages about 5,500 feet in elevation. West-to-east slopes average about 10 feet to the mile. South and west of the Missouri River, the surface mantle and topography have been developed largely by erosion of a fluvial plain extending from the mountains. Within the Great Plains are isolated mountainous areas

The Great Plains Are the Heartland of the Basin

FIGURE 3

PHYSIOGRAPHIC DIVISIONS, PROVINCES, SECTIONS, AND SUBSECTIONS

developed by erosion of dome-type uplifts. Principal among them are the Black Hills in western South Dakota and northwestern Wyoming, an elliptical-shaped area 60 miles wide and 125 miles long. That portion of the Great Plains north and east of the Missouri River, and at places extending south of the river, has been influenced by the continental glaciation. Here, the topography was shaped mainly by erosion of the glacial drift and till.

The Central Lowlands province of the Interior Plains Division, bordering the Great Plains to the east, often does not have a perceptible line of demarcation. Roughly, the 88,000-square-mile area extends from a line between Jamestown, N. Dak., and Salina, Kans., to the Mississippi drainage divide. This entire area has been developed by erosion of a mantle of glacial drift and till. The northern portion is composed of the coarser drift material and the southern portion, the finer till.

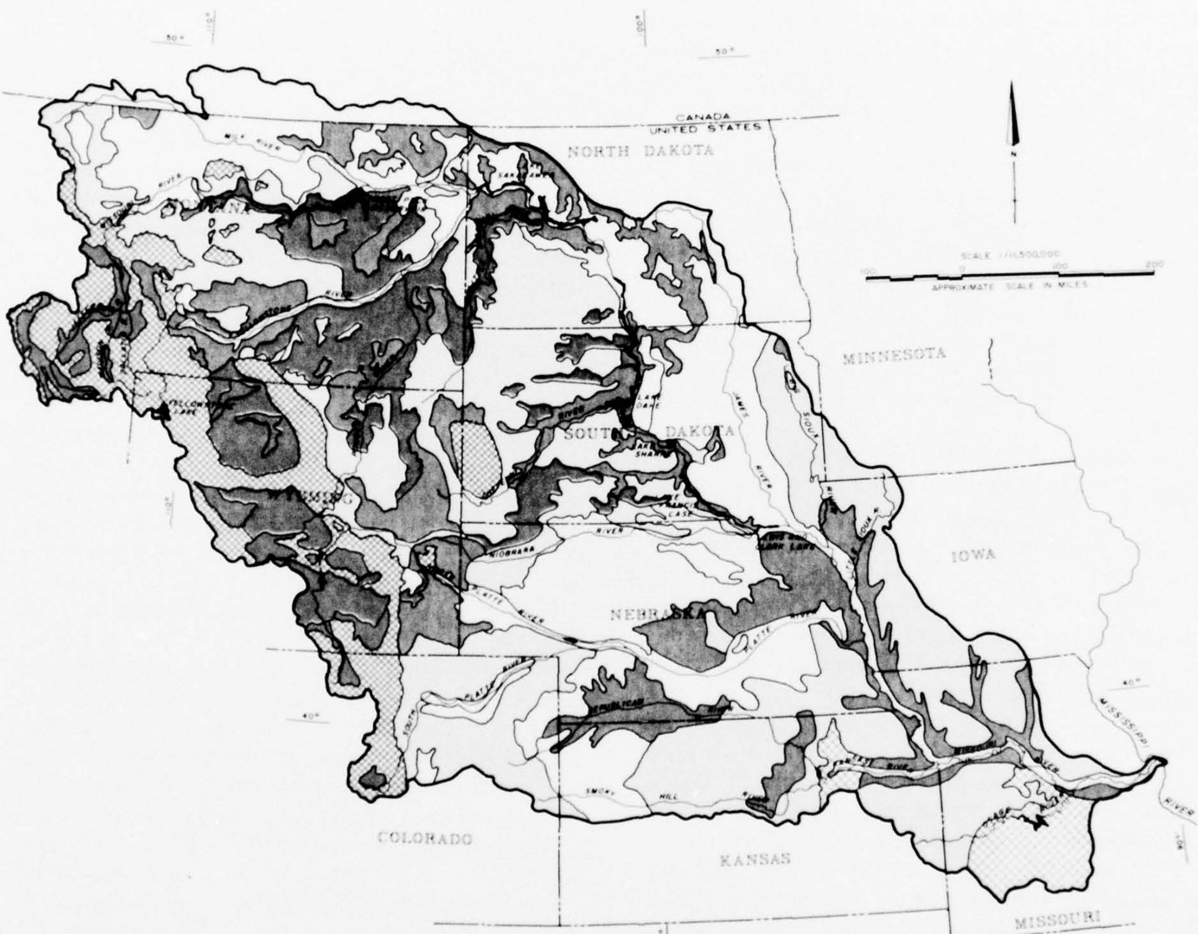
In the southeast portion of the basin, in Missouri, are the Ozark Plateaus, a province of the Interior highlands Division, containing about 11,000 square miles of drainage area. Its topography, developed by erosion of the ancient though moderate Ozark uplift, is hilly to mountainous. This moderate uplift and the underlying sedimentary formations in great depth leave only sedimentary rocks exposed. Limestones are the basic surface materials and gave rise to cavernous channels with spring flows which abound in the area.

Because the basin is so vast and was influenced by a variable geologic historical development, many sectional variations exist, as shown on figure 4. This reflects eight major types of areas, considering soil types and the dominant topographic characteristics.

Areas properly defined as "mountains" include the Rocky Mountains of Colorado, Wyoming, and Montana,

FIGURE 4

PHYSICAL LAND CHARACTERISTICS



LEGEND

- MOUNTAINS
- ROUGH LANDS AND BADLANDS
- HILLY LANDS
- HILLY TO MOUNTAINOUS LANDS
- MODERATELY SLOPING LANDS
- INTERMOUNTAIN VALLEYS
- HUMMOCKY (DUNE) LANDS
- LEVEL AND UNDULATING GLACIAL DRIFT LANDS

and the Black Hills of western South Dakota. Slopes and stream gradients generally are steep, and natural erosion, while slow in most places with heavy vegetative cover and boulder-armored channels, is rapid where soft rocks are exposed. However, the sediment contributed to streams is not excessive.

In the north-central part of the Great Plains and in the large inter-mountain valleys of Wyoming are found the basin's "rough lands and badlands." These are vast and rather high areas where the bedrocks consist largely of silstone, soft shale, clay, and soft and hard sandstones. Natural vegetation is relatively thin, offering little protection from erosion, which is extremely active. Soils generally are shallow, but with some local exceptions.

The "hilly lands" appear intermittently from the bluffs of the Missouri River in eastern Missouri and Iowa to the foothills of the Rocky Mountains. Here, the soils range from shallow to deep, but most are capable of supporting a good natural growth of grasses or trees. Erosion has become very rapid where such lands are cultivated without proper conservation management. Much of the hilly land is grazed, but substantial areas in the eastern part of the basin are used for clean-tilled crops.

In the wooded Ozark Plateau in Missouri south of the Missouri River and in the grassy Flint Hills of Kansas are found the "hilly to mountainous lands." Their parent material is largely hard sedimentary bedrock and the soils range from very shallow to quite deep.

"Moderately sloping lands" are found mostly in areas of soft rocks, glacial till, and loess interspersed with a few reaches of hard rocks. Soils range from moderately deep to very deep, with some shallow soils and rock outcrop. Most of these areas originally supported tall grasses in the eastern parts and short grasses in the dryer western parts, and natural erosion was moderate. Today, a large share of the land is used for cultivated crops, especially in the central and eastern parts of the basin.

"Intermountain valleys" are the areas of the Rocky Mountains in which significant farming occurs. Silty, clayey, or sandy sediments accumulated more rapidly than the streams were able to remove them, and these sediments have formed moderately deep to deep soils which generally show only moderate erosion.

The "hummocky (dune) lands" include the 24,000-square-mile Sandhills area of north-central Nebraska and similar smaller areas in other states. These lands consist of hummocky reaches of loose dune sand currently stabilized by grasses. There are thousands of small basins, some of them semi-marshy and others dry, with many small lakes generally representing exposures of the ground-water table. Soils are generally thin, though the loose-sand deposits are rather thick. An Aeolian topography together with the sandy soils produce very little direct runoff to streamflow, but streams in the area accumulate unusually steady flows, mostly from ground-water accretions. The streams carry much sand sediment derived from their channels and limited tributary drainage areas.

"Level and undulating glacial drift lands" are underlain by alluvium, loess, and glacial drift of greatly varying character. The soils are generally deep to very deep and natural erosion is quite slow. Water erosion is active at higher levels, but the soils washed from the knolls usually collect in intervening basins.

CLIMATE

The basin's climate has a great influence on how its people live and on their socio-economic structure. Obviously, it has a strong influence on the basic agricultural industry, due primarily to the seasonal and variable regimen of precipitation, temperature, and wind.

The climate within the basin is determined largely by the interactions of three great air masses which have their origins over the Gulf of Mexico, the northern Pacific Ocean, and the northern polar regions. They regularly invade and pass over the basin throughout the year with the gulf air tending to dominate the weather in summer and the polar air dominating in winter. It is this seasonal domination of the air masses and the frontal activity caused by their colliding with each other which produces the general weather regimens found within the basin.

Primarily because of its mid-continental location, the basin experiences weather that is known for its fluctuations and extremes. There are also variations between areas within the basin. Winters are relatively long and cold over much of the basin, while summers are fair and hot. Spring is cool, humid, and windy; autumn is cool, dry, and fair. Averages are misleading for seldom does "average" weather actually occur. Instead, weather tends to fluctuate widely around the annual averages, with the occurrence and the degree of the fluctuations being unpredictable; climatic averages have to be thought of as generalizations of the more common occurrences over a period of time.

The one-year minimum precipitation for the entire basin is 70 percent of the long-term average, but one-year minima for the individual subbasins range from 46 to 66 percent of average. Table 1 shows both the minimum annual and 5-year averages of precipitation over the basin and within the subbasins in comparison to the long-term averages.

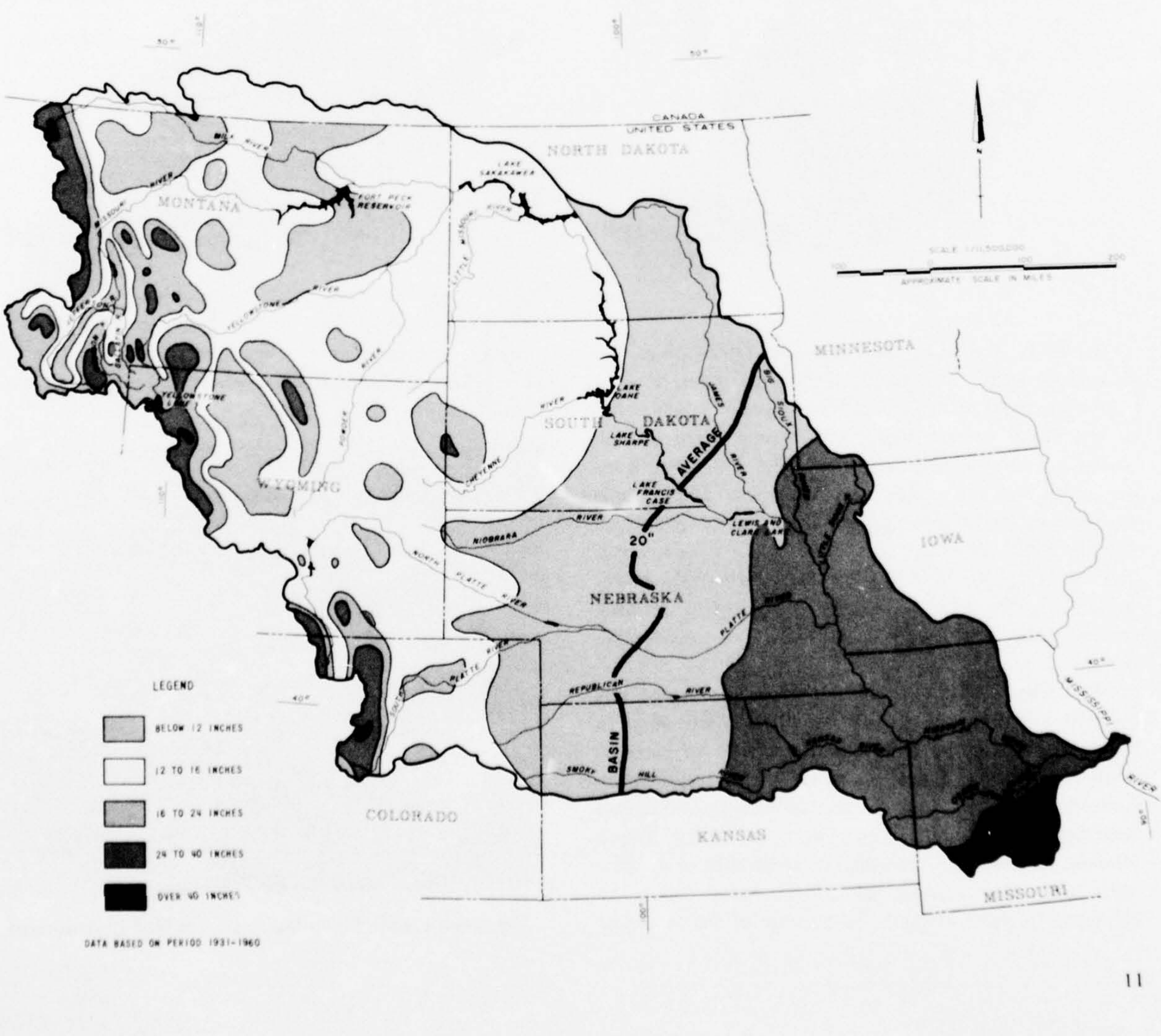
Normal average annual precipitation ranges from about 40 inches in parts of the Rocky Mountains and southeastern parts of the basin to as low as 6 to 12 inches immediately east of the Rocky Mountains. Variation of the average annual precipitation pattern over the basin is shown on figure 5.

Table 1 – MINIMUM ANNUAL AND MINIMUM 5-YEAR AVERAGE VALUES OF PRECIPITATION
MISSOURI BASIN

Subbasin	Minimum Average Precipitation				Long-Term Average
	1-Year	Year	5-Year Average	5-Year Period	
	(Inches)		(Inches)		(Inches)
Upper Missouri	9	1872	12	1933-37	15
Yellowstone	9	1872	13	1933-37	16
Western Dakota	9	1936	13	1933-37	17
Eastern Dakota	11	1864	16	1932-36	20
Platte-Niobrara					
East of 102° Longitude	12	1864	15	1860-64	23
West of 102° Longitude	10	1876	13	1873-77	16
Middle Missouri	13	1843	22	1839-44	29
Kansas					
East of 99° Longitude	13	1843	21	1933-37	28
West of 99° Longitude	11	1894	15	1952-56	20
Lower Missouri	25	1901	30	1952-56	38
Missouri River Basin					
Above Sioux City, Iowa	10	1936	13	1933-37	17
Total basin	14	1936	16	1933-37	20

FIGURE 5

NORMAL ANNUAL TOTAL PRECIPITATION



Precipitation received from November through March is generally in the form of snowfall. Thunderstorms are prevalent in July and August and are often localized, with high-intensity rainfall. Prolonged droughts and lesser periods of deficient moisture may be interspersed with periods of abundant precipitation.

There are periods of extremely cold winter and hot summer temperatures in the basin. Extremes range from winter lows of -60°F. in Montana to summer highs of 120°F. in Nebraska, Kansas, and Missouri. The basin regularly experiences over-100-degree temperatures in summer and below-zero temperatures in winter over most of its area.

One of the climatic factors influencing much of the culture and industry in the basin, particularly agriculture, is the continuous period of above-freezing conditions. The freeze-free period is defined as the average number of days each year between the last 32°F. temperature in the spring and the first 32°F. temperature in autumn. While the freeze-free period does not completely define the growing season for all crops and grasses, it is a general indicator of the most favorable period. It is also an indicator of the period during which special precautions must be taken against freeze-up. Figure 6 shows the average freeze-free period for the basin which, for the non-mountainous areas, ranges from about 90 to 180 days. Mean total hours of sunshine annually are favorable for agriculture and a healthful environment, ranging from about 2400 to 3200 hours, as illustrated by figure 7.

FIGURE 6

MEAN LENGTH OF FREEZE-FREE PERIOD (DAYS)

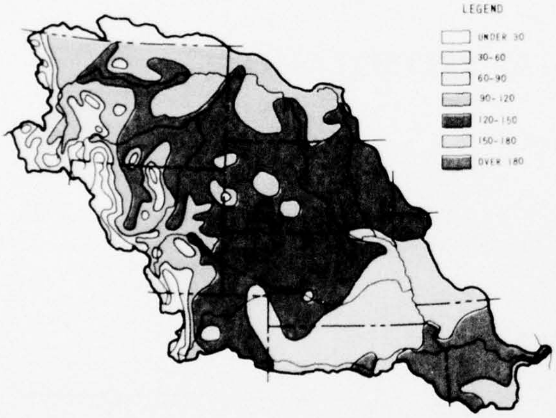
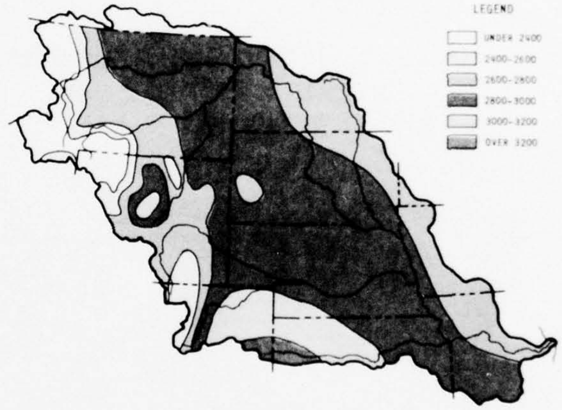


FIGURE 7

MEAN TOTAL HOURS OF SUNSHINE (ANNUAL)



Winds in the basin are the rule rather than the exception, particularly in the plains area. Average wind velocities of 10 miles per hour are prevalent over much of the basin. In the plains area, strong winds accompanied by snow sometimes creat "blizzard" conditions dangerous to both man and livestock. High winds occasionally prevail during periods of high temperatures and deficient moisture that can destroy crops and desiccate rangeland within a few days. Parts of the basin, particularly the south and east, are subject to cyclonic and tornadic winds that occasionally do considerable damage.

Most climatic forces are not amenable to change, but modern technology has done much to enable man to better cope with the extremes that affect his environment and culture. Special farm and range conservation practices, irrigation, and air conditioning in homes and factories are examples. Generalizations of the basin's climate, however, are not always applicable to specific areas or to their seasonal advantages. Many people are attracted to parts of the basin because of the favorable climate, and particularly the cool, dry, crisp days of summer are a tourist attraction in the western and other mountainous areas.

Livestock Losses From Blizzards Are Not Uncommon

SOILS

Soils are associated with the geology of the area but are influenced also by the climate and vegetative development. Complex mountain soils are found in the western perimeter of the basin. Eastern Montana, central and eastern Wyoming, eastern Colorado, southwestern North Dakota, western Nebraska, and western Kansas have Brown Steppe soils. The Chernozems are found in central and eastern North Dakota, eastern South Dakota, and the central parts of Nebraska and Kansas. Prairie soils predominate in eastern Nebraska, western Iowa, eastern Kansas, and western Missouri. These give way to gray-brown forest soils in central and eastern Missouri.

NATURAL RESOURCES

The quantity, quality, and location of natural resources, combined with climatic factors and marketing potentials, influence the type and extent of economic activity within the basin. Beyond the traditional definition of natural resources, such as lands and vegetation, minerals, and water, there is a growing recognition that a high-quality environment has an intrinsic value to satisfy desires for healthful living and recreational relaxation from today's technologically based culture. A brief summary of recreation and fish and wildlife resources is presented herein and further described in chapter 4 as part of the existing situation.

Lands and Vegetation

Earlier descriptive material emphasized the variability of climate, geology, physiography, and soils over the Missouri River Basin. These have influenced the nature of land resources, their usage, and the current pattern of ownership and management. As for all basins, but especially for the Missouri Basin, having a large portion of its area in arid and semi-arid climates, there is a significant relationship between the water and land resources and their joint use to attain a desirable social and economic structure.

Within that portion of the basin in the United States, there are 324,689,000 acres of land and 3,819,000 acres of water, a resource area aggregating 328,508,000 acres. Table 2 illustrates two classifications of land and water usage for the basin and its eight subbasins; primary and joint use, the latter including that of land and water areas ancillary to the primary use. The multiple or joint use made of much of the land or water, such as cropping, wildlife, and scenery, approximates 709 million acres, or over twice the primary use of 329 million acres. A more detailed presentation on land uses may be found in the appendix, "Land Resources Availability."

Dominating the primary uses is agriculture, which accounts for about 312 million acres, or 95 percent of the land in the basin. Well over half of this, 162 million acres, is private pasture and range devoted primarily to

Table 2 – SUMMARY OF PRIMARY AND JOINT USES OF LAND AND WATER AREAS
MISSOURI BASIN

Primary and Joint Use	Subbasin: Upper Missouri	Yellow-stone	Western Dakota	Eastern Dakota	Platte-Niobrara	Middle Missouri	Kansas	Lower Missouri	Missouri Basin
	(Million Acres)								
Agriculture									
Primary	50.4	43.1	47.3	34.4	60.8	14.9	37.2	24.3	312.4
Joint Use	53.7	45.7	51.1	34.5	64.1	15.6	37.7	28.0	330.4
Recreation									
Primary	0.5	1.4	0.3	0.04	0.4	0.04	0.04	0.07	2.8
Joint Use	14.8	13.3	10.7	1.5	8.4	0.2	0.4	1.0	50.3
Fish and Wildlife									
Primary	0.2	0.03	0.1	0.4	0.3	0.06	0.02	0.07	1.2
Joint Use	51.7	44.9	48.3	35.6	62.0	15.0	37.5	24.6	319.6
Transportation, Urban, and Other									
Primary	1.2	0.2	0.9	1.5	1.5	0.6	1.2	0.6	7.7
Joint Use	1.2	0.3	1.5	1.5	1.5	0.6	1.2	1.0	8.8
Water Area									
Primary	0.7	0.3	0.5	0.9	0.6	0.2	0.3	0.3	3.8
Joint Use	0.7	0.3	0.5	0.9	0.7	0.2	0.6	0.3	4.2
Mineral Industry									
Primary	negligible								0.03
Joint Use	negligible								0.03
Military									
Primary			0.3		0.1		0.1	0.1	0.6
Joint Use	—	—	0.4	—	0.4	—	0.1	0.1	1.0
Missouri Basin									
Primary	53.0	45.1	49.4	37.2	63.7	15.8	38.9	25.4	328.5
Joint Use	122.1	104.5	112.5	74.0	137.1	31.6	77.5	55.0	714.3

grazing. An additional 28 million acres of Federal lands are grazed.

Croplands comprise nearly 104 million acres, or 31.6 percent of all lands basinwide, but the proportion ranges from as high as 71 percent in the Middle Missouri Subbasin to as low as 7 percent in the Yellowstone Subbasin. Currently, the irrigated lands aggregate 7.4 million acres, representing about 6.9 million acres of cropland and about 0.5 million in irrigated pastures.

Forest and woodlands total about 30 million acres. These lands contribute commercial timber products, livestock forage, wildlife habitat, and recreation.

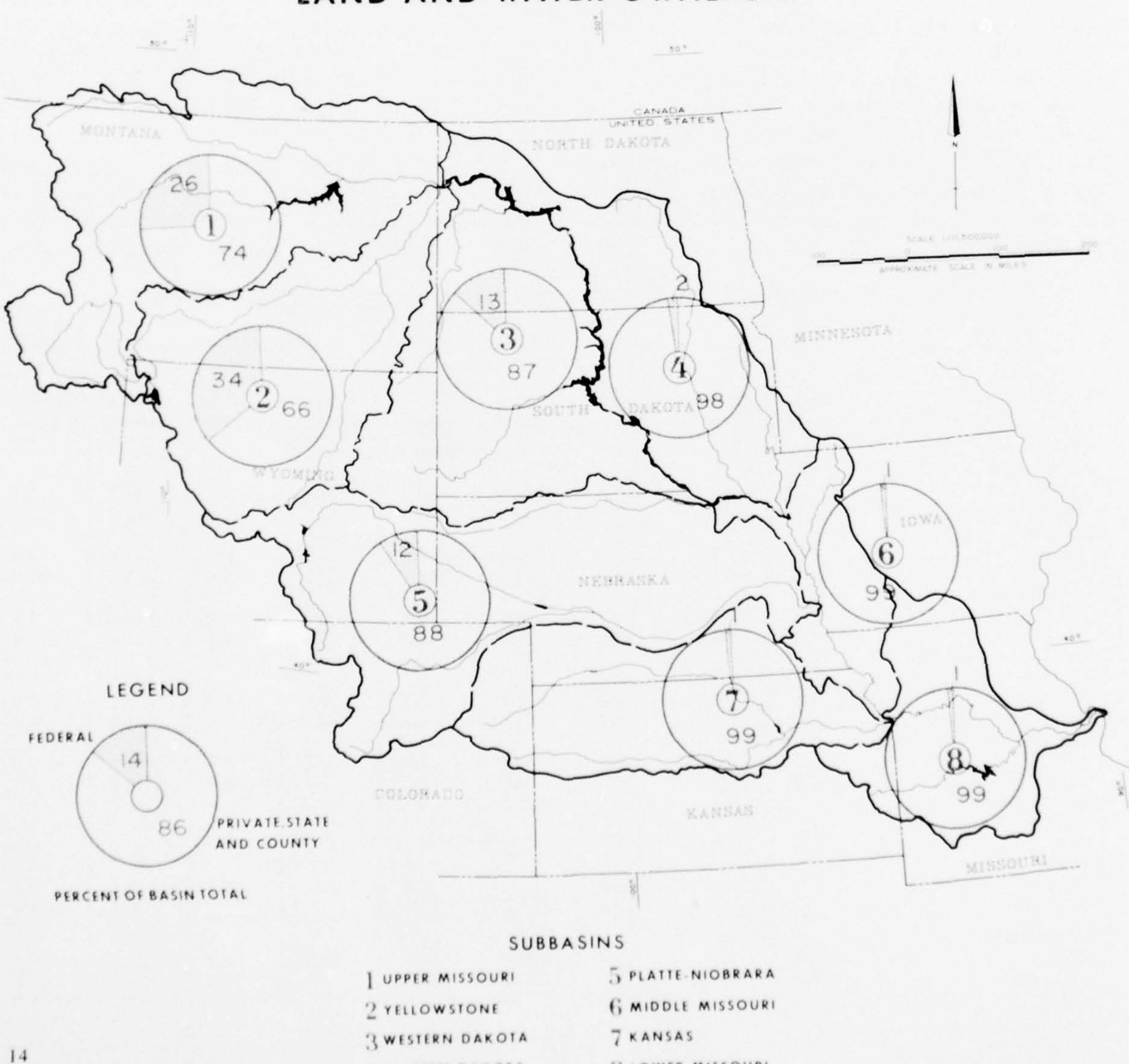
Transportation, urban expansion, and other uses now require 7.7 million acres of land. The mineral industry has surface operation areas of only 33,000 acres, but with underground workings this figure would be higher. Military uses include several military reservations and installations of national importance, including Fort Leonard Wood, Fort Riley, Fort Leavenworth, installations of the Strategic Air Command, and others.

Water areas, aggregating 3.8 million acres, represent but 1.2 percent of the basin area, but are an exceedingly important resource in terms of the function of rivers, lakes, reservoirs, farm ponds, and other water bodies in the regional economy.

Aside from the land-use pattern, the ownership and management of basin lands provide perspective for their private and public values as resources. While in Federal ownership at the time of the Louisiana Purchase, through sales, land grants, and various special and limited homestead acts passed by the Congress, most of the land passed to private and state ownership. Current ownership is illustrated by figure 8.

FIGURE 8

LAND AND WATER OWNERSHIP



Within the "private-county-state" category, with 86 percent of all lands and waters, private individuals are the largest land owners. This includes the state-owned lands represented largely as school grants which comprise 4 percent of the basin total and largely are leased by farmers and ranchers for agricultural use. Over 85 percent of the Federal land is administered by the Forest Service and Bureau of Land Management in about equal proportions. The proportion of private land varies among the subbasins, being smallest in the western subbasins, with large public land areas, and largest in the eastern subbasins.

Mineral Resources

The basin is well endowed with a variety of mineral resources comprising metallics, non-metallics, and fuels, particularly in the mountainous areas and their peripheral outwash plains. Total mineral production in 1960 and each subsequent year has been valued at over one billion dollars.

Metallic mineral resources are found in significant quantities in areas of Montana, Wyoming, Colorado, and in the Black Hills of South Dakota. Gold, silver, copper, lead, and zinc ores have been extracted there in large quantities and known reserves exist. Ferroalloys and other minor metals such as tungsten, vanadium, chromium, beryllium, and lithium have been produced periodically from localized ore deposits. Currently, the sprawling taconite, low-grade iron ore, open-pit operation near Atlantic City, Wyo., and the larger, but not yet completely defined, molybdenum ore body being developed near Empire, Colo., overshadow other metal mining activities. A number of low-grade iron deposits exist in South Dakota and Wyoming. Areas of low-grade chromium mineralization are known, and recent copper and molybdenum explorations have been made along the Continental Divide. Open-pit uranium mines are operating in Wyoming.

Non-metallic minerals of the basin include a broad array of such construction materials as sand, gravel, stone, and clay, several fertilizer minerals, and numerous minerals for chemical and other miscellaneous uses. Almost every county in the basin has recorded the annual production of non-metallics, primarily to meet local construction industry needs. The more valuable chemical and fertilizer minerals are processed locally and marketed regionally, nationally, and, in a few instances, worldwide. Bentonite clay production in Wyoming, used extensively in oil well drilling, phosphate resources along the western edge of the basin, and gypsum and cement minerals in many sections of the basin are some of the non-metallic minerals that have promise for future development.

Minerals fuels as a group constitute the greatest mineral resource now in production in the basin. Currently, the annual oil and gas production accounts for about two-thirds of the total value of mineral output in the basin. Basinwide production of the petroleum industry has increased since World War II, paralleling a national trend. Proven reserves in Montana, Wyoming, Colorado, South Dakota, Nebraska, and Kansas approximate a 10- to 12-year supply at the current rate of production and usage.

For all practical purposes, coal reserves in the basin are almost infinite. The Missouri Basin States have more than 450 billion tons of recoverable coal reserves, or about 55 percent of the Nation's total known recoverable reserves. The upper basin States of North Dakota, Montana, and Wyoming possess the bulk of the reserves, with at least 350 billion tons of recoverable coal. However, with the exception of Nebraska and the small southwestern section of Minnesota, all basin states have substantial coal reserves.

Forest Resources

While much of the basin is not conducive to timber growth, about 30 million acres, or 10 percent of the land, supports sufficient cover to be classified as forest. Of this total, 73 percent is in the Rocky Mountains and Black Hills which support timber stands of Lodgepole

White Oak is Found in the Ozark Plateau Area of the Basin

pine, Douglas fir, true firs, and Ponderosa pine. Twenty-three percent of the forest land is in the Ozark Plateaus where the chief timber types are oak-pine, oak-hickory, elm, ash, cottonwood, and other hardwoods.

Water Resources

Water is one of the basic resources necessary to sustain life, and its abundance or scarcity influences the culture, economic structure, and environment for human habitation. The variability of this influence is especially evident in the Missouri River Basin from its more densely populated humid eastern sections to the more sparsely populated and generally arid western sections.

Both the form and magnitude of water resources available for use vary considerably within the basin. Precipitation varies in form and in the amount received seasonally and annually. Runoff is, in part, predictable seasonally where the precipitation is received as snowfall and builds up during the winter, particularly in the mountainous areas. Conversely, rainfall is largely unpredictable, and may be received in the form of intense storms or relatively light falls spaced intermittently. Periods of drought are not uncommon in some parts of the basin in any year, or a succession of two or more years, and occasionally throughout the basin, as in the 1930's.

As can be noted from the average annual precipitation values shown earlier in figure 5, much of the basin receives, on the average, less precipitation than the vegetative consumptive-use demand or potential evapotranspiration. This situation not only dictates the type of vegetation naturally adapted or that can be grown in the climatic zones already illustrated, but it also influences the runoff. In many areas, runoff is experienced only when the precipitation intensity exceeds the ability of the soil to absorb it.

Since the beginning of settlement in the basin there has been progressive development and management of water resources to support the population and economic activity. Existing storage reservoirs in the basin have a gross capacity of over 106 million acre-feet serving such purposes as municipal, industrial, livestock, irrigation, power, low-flow augmentation, fish and wildlife, recreation, and flood control. In addition to the storage of surface waters, diversions of water for beneficial uses are also made from both streams and from ground water.

Any analysis of water resource availability within the basin must be associated with an understanding of the following principles:

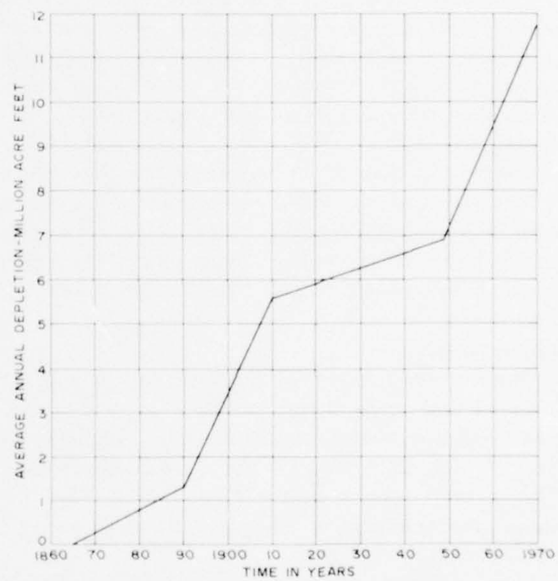
(1) Historic streamflow measurements are not indicative of current conditions or water availability without adjustment for subsequent utilization, storage control, and cultural land practices.

(2) Ground-water utilization in the basin affects streamflow in varying amounts, depending on the hydrologic relationships of the ground-water aquifers with the streams.

(3) Water visibly appearing in streams or impoundments must be analyzed in conjunction with dedicated water rights, interstate compacts and court decrees, and current usage to determine its availability for new and additional uses.

Prior to 1865, streamflow of the Missouri River was largely unused, but about this same time the influx of the early settlers of the basin started irrigation and mining ventures. By 1890, streamflow depletions in the basin averaged about 1.3 million acre-feet annually and by 1910, they averaged 5.6 million acre-feet annually. Between 1910 and 1949, water uses increased at a much slower rate with streamflow depletions reaching an average annual level of 6.9 million acre-feet by 1949. Since 1949, the major features of the basin plan, known as the Pick-Sloan Plan, were initiated. This acceleration since 1949 has added to streamflow depletions by about 4.8 million acre-feet. Figure 9 illustrates the growth of streamflow depletions in the basin.

FIGURE 9
GROWTH OF STREAM FLOW DEPLETIONS
IN THE MISSOURI RIVER BASIN



Runoff is the amount of precipitation that appears in surface streams. However, it is the same as streamflow only when unaffected by artificial diversions, storage, or other works of man. Some streamflow records within the basin are fairly representative of natural runoff and others, with minor adjustment, are useful for such a determination. In all, the records of 483 gaging stations within the basin and 57 peripheral stations were selected

for analysis. From this analysis, the mean annual historical runoff in inches was computed for the basin to give the pattern shown on figure 10.

A description of the floods that have occurred in the basin would be too voluminous to include here. Such descriptions are included in annual flood reports pre-

FIGURE 10

MEAN ANNUAL RUNOFF (Inches)

pared by the Corps of Engineers, in U. S. Geological Survey Water Supply Papers, and in other reports by the States and Federal agencies. In order to establish storage volume requirements for flood control purposes and for selection of design floods for in-stream control, high flow volume duration frequency data were developed.

Historic streamflow records show that the average annual outflow of the Missouri River recorded at Hermann, Mo., near the mouth, was 56,710,000 acre-feet for the period 1898-1966. In its then-largely-unregulated state, annual extremes in streamflow recorded at Hermann ranged as high as 105 million acre-feet in 1915 to as low as 22 million acre-feet in 1934. However, streamflow records reflect constantly changing levels of water resource development and streamflow depletion, and must be adjusted to a current level of water resource development, water uses, and streamflow depletion. Accordingly, available streamflow data for the basin have been adjusted to the level of water resource development that is anticipated by 1970. This includes the estimated uses and water depletions associated with the existing developments, and for those water resource projects now under construction. On this basis, it is estimated that current average annual water depletions would reduce the average annual basin historical outflow at Hermann to 53.6 million acre-feet.

For planning purposes, 110 stream-measuring locations were selected throughout the basin and the

monthly flows at the 1970 level of development were computed, as for Hermann. Table 3 shows the average percent contribution from the eight subbasins to the average annual flow of the Missouri River under 1970 conditions. The eight subbasins contribute 55.5 million acre-feet of flow which is subject to an additional 1.9 million acre-feet of main stem reservoir evaporation and other depletions, leaving a net basin outflow of 53.6 million acre-feet.

Table 3 – SUBBASIN FLOW CONTRIBUTIONS TO THE MISSOURI RIVER

Subbasin	Drainage Area		1970-Level Flow	
	Thousand Sq. Mi.	Percent of Basin	Million Ac. Ft.	Percent of Basin
Upper Missouri	92	17	7.7	14
Yellowstone	71	13	8.8	16
Western Dakota	77	15	2.4	4
Eastern Dakota	58	11	3.2	6
Platte-Niobrara	99	19	4.2	8
Middle Missouri	25	5	7.7	14
Kansas	61	12	4.2	8
Lower Missouri	40	8	17.3	30
Subtotals	523	100	55.5	100
Main Stem Depletions			-1.9	
Missouri Basin (Hermann, Mo.)	523	100	53.6	100

Surface-Water Quality

Pure water in streams and lakes is practically unavailable. Water is a solvent and it dissolves and carries in solution certain materials derived from the soils and rocks over which it flows or through which it percolates. In addition to the natural sources of dissolved solids, human activity in many endeavors either directly or indirectly contributes dissolved solids to streams. Streams also may transport many undissolved solid wastes accumulated from natural overland runoff, or deliberately discharged to the streams as wastes. The following paragraphs highlight the present quality of surface waters, while more detail may be found in the appendix, "Hydrologic Analyses and Projections."

Water quality is judged largely in terms of the requirements of the various water uses. Within the Missouri Basin, the primary water uses are domestic, industrial (including power generation and cooling water), irrigation, recreation, fish and wildlife, and navigation. Water quality demands vary for each use, and also may vary within a region for a given type of use.

The principal water quality characteristics that concern the suitability of water for uses within the basin are the dissolved solids content that affect the health of humans and plant and animal life; temperatures that affect the fishery and aquatic environment; pathogens that affect health; and taste, odor, and floating materials that may affect adversely the potability of the water and the general environment. Bacterial and biological pollutants in the form of micro-organisms may not only endanger health, but also may reduce the dissolved oxygen content of streams and lakes and make them less desirable as fishery habitat. Temperature is a quality that is often complex in its effect upon the biological regime and fishery habitat. Undissolved solids such as sludges, floating material, oils, and sediments are visible and, when observed, often generate a demand from the public for remedial measures. Quality standards for the various uses of water in the Missouri Basin are discussed in the appendix "Present and Future Needs."

The amount and kinds of water quality data obtained within the basin largely have been responsive to problems encountered in the use of water. Historically, and aside from bacterial and biological aspects, the principal concern has been the concentration of those dissolved solids that affect domestic, industrial, and irrigation uses. Figure 11 shows the total dissolved solids concentration in milligrams per liter for general areas as derived from 77 stream-sampling stations. Similar additional data were derived for critical parameters such as sulfates, chlorides, and sodium adsorption ratios.

Temperature data have been obtained at several stream-sampling stations within the basin and, in general, average water temperatures are approximately the same as the average daily air temperatures, except as affected locally by thermal pollution.

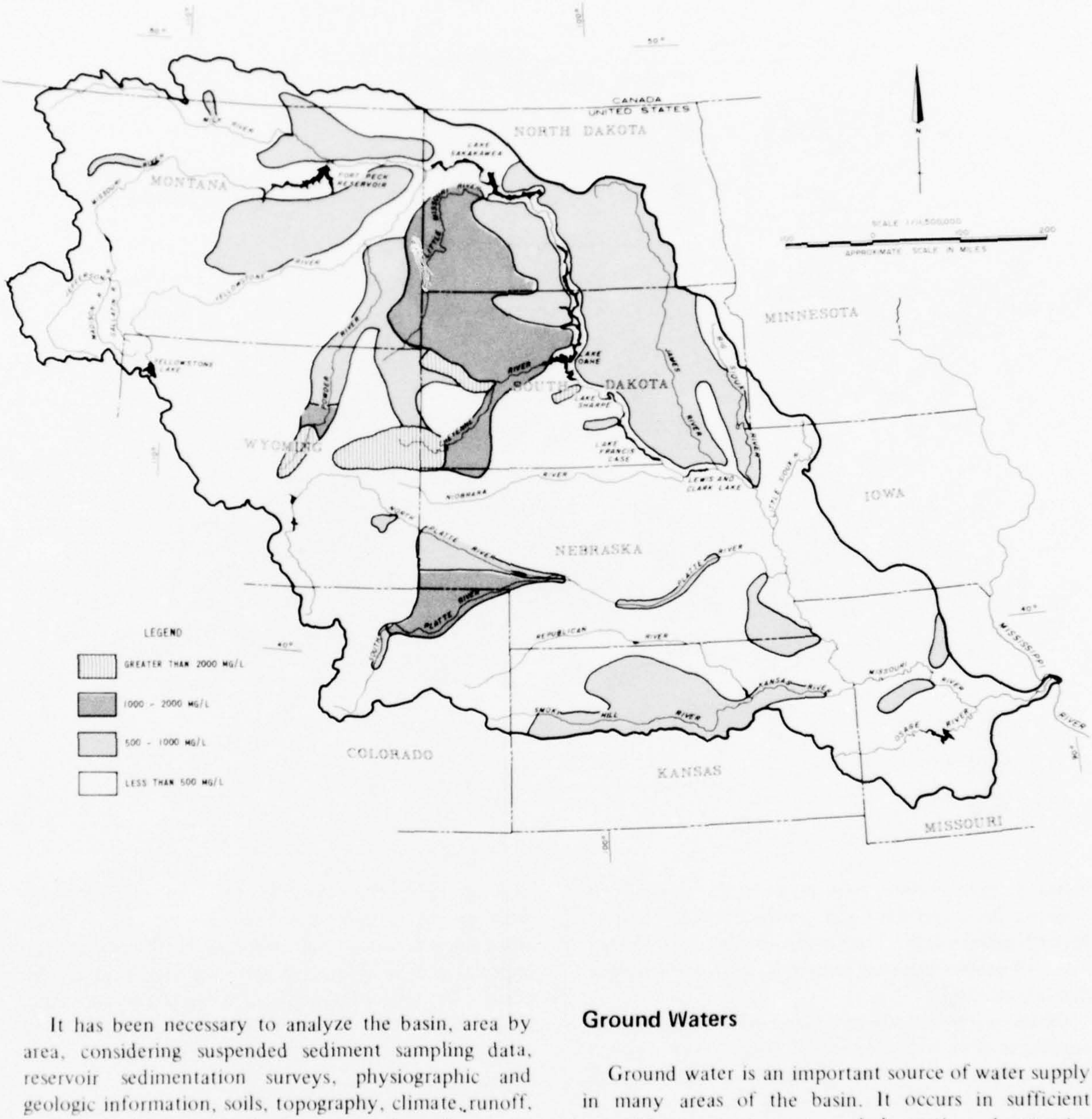
There has been no systematic program for obtaining biologic data or dissolved oxygen data on an area-wide basis. The data that are available have been obtained in association with problem areas as discussed in the appendices "Hydrologic Analyses and Projections" and "Present and Future Needs."

Sediment

From the standpoint of erosion characteristics and sediment contributed to streamflow, the Missouri Basin is a diverse area, and to develop simple formulae for a determination of sediment yields within the basin is impossible.

FIGURE 11

TOTAL DISSOLVED SOLIDS IN SURFACE WATER



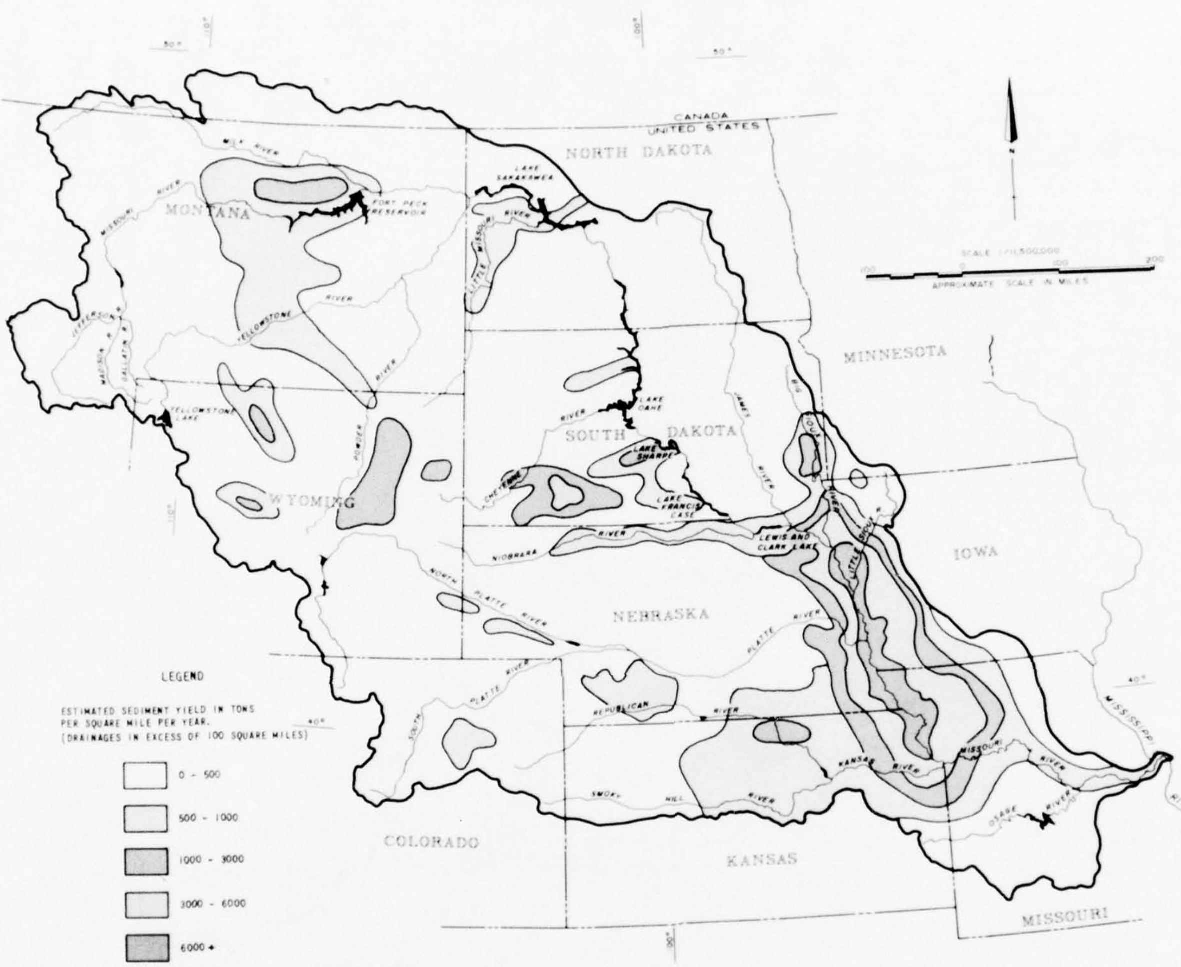
It has been necessary to analyze the basin, area by area, considering suspended sediment sampling data, reservoir sedimentation surveys, physiographic and geologic information, soils, topography, climate, runoff, vegetation, land use, upland erosion, channel erosion, and present knowledge of sediment transport and delivery. With these as a basis, it was possible to develop estimates for average annual sediment yield in tons per square mile applicable to drainages in excess of 100 square miles. Figure 12 shows the probable ranges of average annual sediment yield for various areas in the basin.

Ground Waters

Ground water is an important source of water supply in many areas of the basin. It occurs in sufficient quantities to meet most rural domestic and extensive livestock needs, and has enabled agriculture to expand into many areas remote from perennial streams. Further, its abundance generally has permitted municipal, industrial, and irrigation development where surface-water supplies were inadequate for these purposes. Ground-water effluent provides a base flow for many streams that otherwise would flow only after runoff-

FIGURE 12

SEDIMENT YIELD



producing precipitation. In some cases, the stream beds lie above the water table and the streams lose water to the underlying aquifer. The relationship between streamflow and ground water is extremely complex in many areas of the basin.

Of the water beneath the land surface, only that in permanent or virtually permanent zones of saturation is called ground water. Any saturated material through which water can move fast enough so that it can be produced from wells is termed an aquifer.

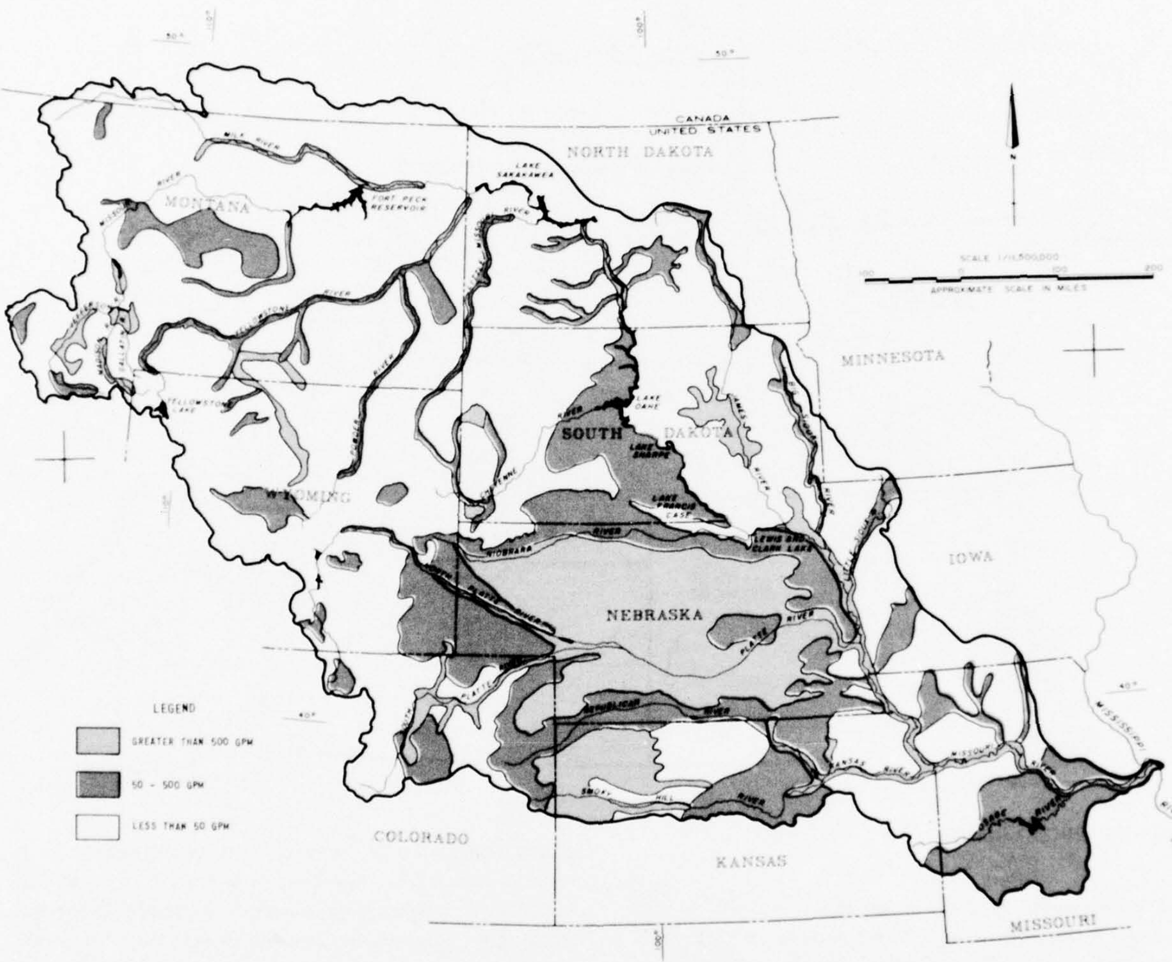
Unconsolidated coarse-grained sediments, such as well-sorted sand and sandy gravel, have the greatest capacity for both storing and transmitting water; accordingly, they are the most productive aquifers. All water in the zone of saturation is moving towards points of discharge at the land surface. The rate of movement is very slow, generally ranging from a small fraction of an inch to no more than a few feet per day. Natural discharge of ground water to streams or through evapotranspiration occurs continuously. Basin-wide, the principal source of ground-water recharge is precipitation that infiltrates the ground and percolates downward to the water table. In a few areas, the ground water is recharged, in part, artificially by the residual from irrigation of surface soils.

Ground-water availability has been estimated from the best geologic and hydrologic data available. While extensive studies have been made by the States and the Federal Government over many parts of the basin, many areas lack sufficient data for other than judgment estimates of ground-water availability. Basically, the quantity of ground-water resource has been evaluated as that available to properly constructed wells for areas in the Missouri Basin that also show a chemical quality

generally satisfactory for most uses. As shown in figure 13, large areas in Nebraska and Kansas and other scattered locations, including a few river valleys, show quantities generally available where the estimated yield per well exceeds 500 gallons per minute. However, much of the western and northeastern portions shows less than 50 gallons per minute.

FIGURE 13

AVAILABILITY OF GROUND WATER

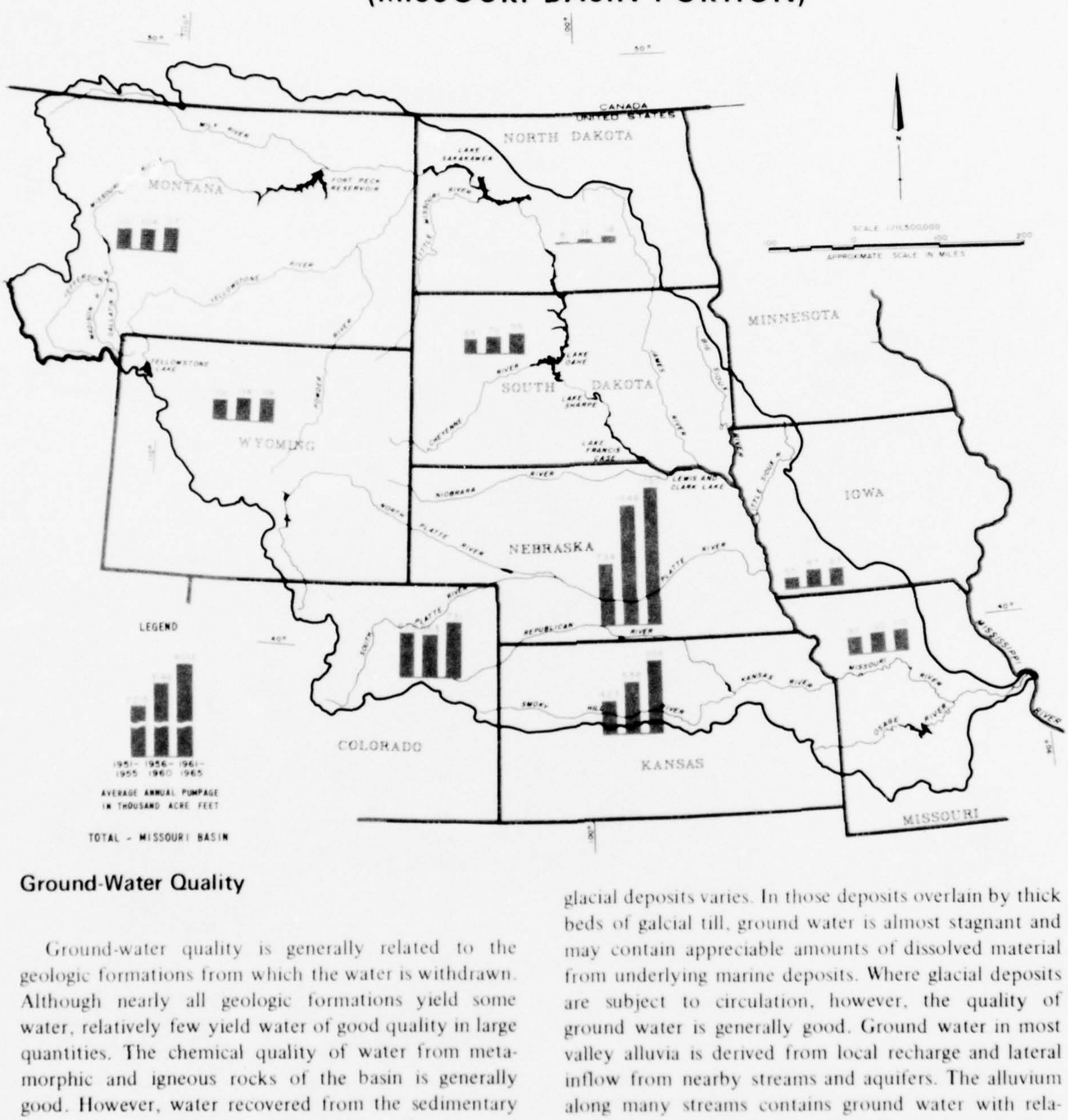


Long stretches of several stream valleys between the mountains and the glaciated part of the basin contain alluvial deposits generally capable of yielding moderately large to large quantities of water to wells (300 gallons per minute or more). These deposits underlie not only the flood plains, but also terrace remnants bordering the flood plain. Estimates of the average annual ground-water pumpage for each State, based on the limited data available, were made for three different 5-year periods, as shown on figure 14.

In some areas, the increasing withdrawal is causing a decline in the ground-water table. Some decline in water table should be anticipated, and adjustments in the natural hydraulic characteristics of the aquifer most often will rebalance the changed conditions due to the withdrawals. However, progressive water-level declines in some areas, that may be indicative of over-use, are causing concern to the pumpers. Although deeper aquifers and yield large volumes of water, these waters are highly mineralized. The withdrawals for irrigation constitute the greatest single use of ground water and far exceed all other uses combined.

FIGURE 14

GROUND-WATER WITHDRAWALS BY BASIN STATES (MISSOURI BASIN PORTION)



Ground-Water Quality

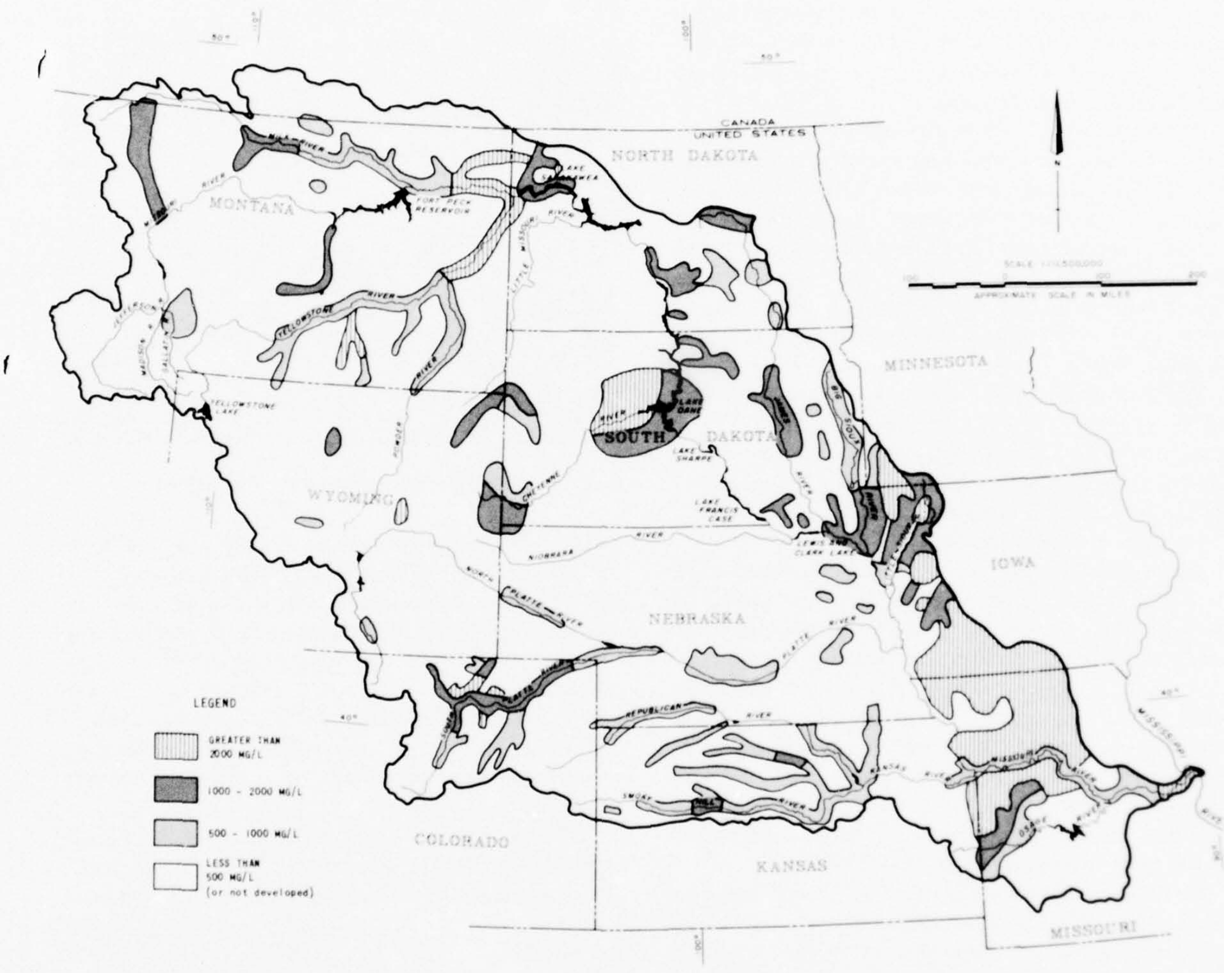
Ground-water quality is generally related to the geologic formations from which the water is withdrawn. Although nearly all geologic formations yield some water, relatively few yield water of good quality in large quantities. The chemical quality of water from metamorphic and igneous rocks of the basin is generally good. However, water recovered from the sedimentary rocks ranges in chemical quality between the saturated brines found in deeply buried marine rocks to water with total-dissolved-solids concentrations less than 100 milligrams per liter found in certain near-the-surface formations. Most water originating in dune-sand areas is of good quality, as that in the Sand Hills of Nebraska. Water originating in loess is somewhat more mineralized since calcium carbonate usually is present below the zone of weathering. Chemical quality of water from glacial deposits varies. In those deposits overlain by thick beds of galcial till, ground water is almost stagnant and may contain appreciable amounts of dissolved material from underlying marine deposits. Where glacial deposits are subject to circulation, however, the quality of ground water is generally good. Ground water in most valley alluvia is derived from local recharge and lateral inflow from nearby streams and aquifers. The alluvium along many streams contains ground water with relatively high concentrations of sulfates derived from nearby rocks rich in gypsum. Where ground-water use is high and alluvium aquifers are subject to recharge from streams, ground-water quality is controlled in part by the quality of the water in the stream.

The vast size of the basin and the range that exists in the parameters of water quality make impractical a detailed presentation of all available data concerning quality of ground waters in the Missouri Basin. While

some ground water is used in limited quantities for various purposes throughout the basin, data have been assembled only for aquifers capable of yielding 300 gallons or more per minute. Figure 15 shows the total dissolved solids in ground water of selected aquifers. Data on other quality parameters are presented and discussed in the appendix, "Hydrologic Analyses and Projections."

FIGURE 15

TOTAL DISSOLVED SOLIDS IN GROUND WATER



Recreation, Fish, and Wildlife

From the rugged mountains in the west to the densely wooded hills and meandering streams of the Ozark Plateaus in the southeast, the basin offers a myriad of varying outdoor recreational resources and opportunities. It contains some of the best known developed recreation areas in the United States, including Yellowstone, Glacier, and Rocky Mountain National Parks, the Black Hills region, Custer Battlefield National Monument, and the Lake of the Ozarks region.

The basin's recreation resources fall into three major geographic areas having different climatic characteristics: the Rocky Mountains and Black Hills, the central plains, and the Ozark Plateaus of southern Missouri. These resources have been classified into three general types: scenic, historical, and natural (type I); land-oriented (type II); and water-oriented (type III). Historic monuments and national forests are included in the type II classification, and reservoirs and lakes where water is the main attraction are in type III. In all there are some 5,200 public recreation areas in the basin, with approximately 3 million acres in type I, 42 million acres in type II, and about 3 million acres in type III.

Public recreation lands comprise 15.2 percent of the total basin area, and probably 98 percent of the total

public and private land and water area devoted in some respect to recreation. National parks, national monuments, and other areas administered by the National Park Service make up about 97 percent of the type I acreage, accounted for largely by Yellowstone, Glacier, and Rocky Mountain National Parks. National forest and grasslands, public domain lands, and Indian reservation lands comprise about 97 percent of the type II land and water. Nearly all of the sizable units are in the western half of the basin and provide the bulk of the sightseeing, hiking, and hunting. Local parks, Federal reservoirs, and State parks and recreation areas provide most of the type III lands and water acreage.

Within the type I and II areas are about 4.5 million acres of lands that are now receiving preservation protection and qualify as wilderness areas. Of this total, 4 percent by acreage is designated as roadless area, 16 percent as primitive area, 35 percent wilderness area, and 45 percent National Park Service areas. The National Park Service areas are not specifically designated as wilderness, but represent sufficient wilderness values to be so considered.

The basin also supports an unusual variety of fish and wildlife species, often in a pristine environment. Their value is principally for sport hunting and fishing, and a growing environmental, aesthetic, and scientific interest. Certain fur-bearing animals and many kinds of fish have a significant commercial value.

Ninety-seven percent of the basin's 329 million acres of land and water provide habitat that is important in varying degrees for fish and wildlife. Only 0.3 percent is devoted exclusively to fish and wildlife use, but an additional 2.7 percent is of primary consideration in multi-purpose management. Most of the area used is privately owned and the fishery or wildlife use is ancillary to other purposes. Currently, about 44,000 miles of streams and 1.4 million acres of lakes and reservoirs provide an estimated 43 million fisherman-days of sport fishing capacity within the basin.

Wildlife populations are as varied as the wide range of habitat that supports them. About 60 species of big game, small game, and waterfowl are sought by sportsmen. About 20 of the species are important for their fur.

There are an estimated 2.5 million acres of wetlands valuable to waterfowl in the basin. These wetlands support an estimated 2.2 million wintering waterfowl and about 2.4 million of breeding waterfowl. Shallow fresh marshes, deep fresh marshes, open fresh water, and seasonally flooded basins constitute the bulk of these wetlands.

Wetlands Are Essential For Waterfowl

In recent years the annual harvest within the basin has been about 1 million birds. However, the value of the basin's wetlands resources for waterfowl cannot be appraised solely on the within-basin harvest, because they supply breeding and resting habitat vital in the international migratory pattern of the Great Central Flyway. Waterfowl populations have shown a marked decline in the past 15 years and the lower population within the Central Flyway has required severely regulated harvest controls.

Indicative of the wildlife resources in the basin is the number of game animals taken by sportsmen annually. Currently, about 15 million game animals are harvested annually, about 75 percent of which is small game and the remainder equally divided between big game and waterfowl hunting.

CHAPTER 3

SOCIAL AND ECONOMIC CHARACTERISTICS

The Missouri River Basin contains a potpourri of social and economic characteristics. In part, it mirrors the Nation, and, in part, it is wholly unique in its character. Some of its socio-economic traits are common throughout its territory, but there are others which have significant special variations. The result is that the basin can be separated into a number of sub-areas, each of which has cultural traits that sets it apart from the rest.

The basin's social and economic characteristics have largely been the result of its settlement history. Three elements of that history are of particular interest. First, is the relationship of the people of the basin to their environment and the unique cultural traits which have resulted. Second, is the distinct patterns of livelihood which have developed during the settlement period. Third, are the attitudes toward change which tend to be prominent among various groupings of the basin's people.

THE SETTLEMENT PERIOD

The initial settlement period started about 1800 and ended with the closing of the frontier in 1890. During this time, most of the arable land was claimed and put to agricultural uses. However, land use and settlement densities varied greatly and were determined largely by two factors; the availability of transportation and the extent of easily exploitable natural wealth.

Exploration and travel into and about the basin during the first half of the 19th century had St. Louis as a focal point. Three routes were open to the traveler looking west from St. Louis; to the southwest along the Santa Fe Trail, to the west over the Oregon Trail, and to the northwest along the Missouri River. The importance of these routes as the means for traversing the Great Plains by traders, the military, and settlers has been well documented. However, they have a special significance to the basin. Places such as St. Louis, Independence, St. Joseph, Kansas City, and Omaha had their origins as starting points or way stations for the westward traveler. The cities along the Missouri River became particularly important for they acted as the gateways to the settlement of the basin. From the first settlement to the present, most of the goods that were needed within the basin and the products it exported passed through these gateways.

The settlement of the basin proceeded somewhat slowly and unevenly prior to the Civil War. From the state of Missouri, settlement spread westward along the Kansas River and northward along the Missouri. Settlers also pushed into the western portions of Iowa and Minnesota. This settlement along the humid eastern edge of the basin was little different from that which had occurred east of the Mississippi River. However, the push from the east tended to falter and stop along the edges of the Great Plains. By 1850, the settlement frontier was relatively stationary along the 97th Meridian.

The explorations and surveys of the plains portion of the basin during the first half of the 19th century classed this area as a desert and unfit for agriculture, at least as it was known in the more humid east. As settlement reached the edge of the plains, it was apparent that the technology which had made possible the opening of the eastern United States was not adequate to overcome the obvious hazards of the plains. Transportation, water, building materials, fencing, and the Indian all were problems that the pioneer was not able to cope with at this early date.

The area west of the 97th Meridian became a land to cross, at best a base of operation, and little more than a barrier to the riches of the Pacific Coast. The war with Mexico, the attachment of California, and the settlement of the dispute with Great Britain over Oregon were the interests that occupied the attention of the pioneer, the miner, and the statesman. The white man did not make a determined effort to live on the plains portion of the basin until after the close of the Civil War.

The Kansas-Nebraska Act of 1854 established two separate territories, the first on the west side of the Missouri River. The act stipulated that the people who settled in the new territories were to decide for themselves whether or not to legalize slavery. Partisans for both sides of this political question rushed to occupy the new land and produced the first settlement boom of consequence.

The availability of the new land was certainly a stimulus to the resulting influx of settlers into Kansas and Nebraska. However, a major contributing reason was

a desire by a large number of the settlers to insure the establishment of certain deep convictions and opinions they had developed back home. Many of the settlers chose this area of the frontier because of their desire to increase the voting power of either the North or the South in regard to the slavery question and the other issues which divided the Nation at the time. Because of their preoccupation with the transplanting of institutions developed in the east, few were prepared to adapt to the environment of the plains. Consequently, the drama of conflict which preceeded the Civil War in these territories was confined to the more humid area east of the 97th Meridian.

The decade of the 1850's produced a rapid migration to the Pacific Coast. By 1860, a western settlement frontier had been established. It was composed of people who had jumped the basin in the initial rush to find gold in California or land in Oregon and who began to backtrack into areas which had been ignored earlier. In the region between this western settlement frontier and the settlement line along the 97th Meridian lay approximately one-third of the territory of the United States, but in 1860, this area probably contained less than one percent of the population.

With the passage of various settlement acts in the 1800's, land was made available to settlers for nominal fees. Most changes from the earlier to the later acts were in the interest of increasing the individual land holdings. Some of the changes advocated were obviously the result of selfish interest, but many were based on a realistic appraisal of the agricultural situation in the Western United States.

Following the gold rush to California, numerous prospecting parties entered the Rocky Mountains. Gold was found in the Pikes Peak region of Colorado in 1859 and an estimated 100,000 people reached the area the first year. Although many of the people in this first influx later moved on to other discoveries, those who remained laid the foundation for the establishment of the Territory of Colorado in 1861. Denver was founded during this gold rush and, even though the gold deposits in its vicinity were significant, it became more important as a major transportation and service center for other mining areas within the Colorado Rockies.

The rush that laid the foundation of Colorado was but one of a series of booms which formed the economic base for a number of scattered settlements. Gold discoveries in 1863 gave birth to Alder Gulch and to Virginia City in Montana. Ten thousand people came to Virginia City in 1864 and the same year saw the founding of Helena. The mining population was large enough to warrant the organization of the Territory of Montana in 1864 and the Wyoming Territory in 1868.

In the 1860's, it was found that cattle not only could withstand the severe winters of the plains portion of the basin, but would thrive on the pasturage of wild grasses. Consequently, the first whites to attempt permanent settlement of the plains were the cattlemen. Though of great influence in parts of the basin today, the period of their domination was brief, lasting from the time of the Civil War to about 1900, when they were largely driven aside by the advancing frontier of farmers.

The rapidly growing population of the East and the railroads advancing to the edge of the plains offered both a market and a means of transportation, opportunities that quickly established the cattle industry in the basin. The cattle boom towns of the period included Abilene and Dodge City, Kans.; Ogallala and Sidney, Nebr.; Pine Bluffs and Rock River, Wyo.; and Miles City, Mont.

It is interesting to note that even though the gateway cities along the Missouri and some of the mining towns grew to regional importance, by and large the same did not occur to the cattle centers. Most of these towns still persist and many perform virtually the same functions as they did in the 1880's, but none attracted the institutions and industry necessary for regional domination. Perhaps the reason is to be found in their transportation roles. As railheads, they served a vital economic function, but when the rails were pushed farther west, they lost much of their status and became just service centers along the tracks.

Even though the cattlemen's frontier was short, it left some definite influences on the history of the basin. It helped dispel the concept that the plains were a desert and aided in the opening to settlement of the vast area between the 97th Meridian and the Rockies. The dependence of the cattlemen upon free land added to the pressure put upon the Federal Government to give free land to the farmer. With the growth of cattle raising on the plains, the packing industry moved westward to center in Chicago, St. Louis, Kansas City, and Omaha. This helped cement the position of the cities along the eastern edge of the basin as the center through which all the goods into and out of the plains passed. The conflict between the cattlemen on the one hand and the packers and the railroads on the other for the profits of the industry contributed to the economic and political controversies of the first decades of the 20th century and to the rising unrest of the agriculturalists.

Probably most important was that the cattlemen were able to devise an economic and social system which was adapted to the physical environment of the plains. Their use of the available resources, while probably not very efficient, was much less harmful than what followed during the farmer's frontier. The cattlemen adapted their stock raising to the physical limitations found on the plains; they maintained the mobility to respond to climatic fluctuations and markets; and their institutions were fairly flexible and tailored to the plains environment. Today, after some 80 years of settlement history, much the land within the basin is still best suited to the

grazing of livestock in much the same manner as was done during the late 1800's. No better economic use has been found for this land.

The period of major railroad construction within the basin occurred between 1865 and 1885. Of most significance was the linking of the West and the East by the Kansas Pacific, the Burlington, and the Union Pacific railroads and the crossing of the northern portion of the basin by the Great Northern and Northern Pacific lines. The railroads insured the roles of the eastern gateway cities to their dominance over the commerce of the basin. To the cities already listed were added Minneapolis and somewhat later, Sioux City. Primarily because of the east-west nature of the mainlines of the railroads, the major economic regions tend to be a series of east-west strips across the basin each with a gateway city at its eastern edge.

Many of the railroads were the recipients of large public land grants. It was, therefore, essential for the railroads to populate the area. Their literature and advertisements were printed in many languages and distributed over the Eastern States and Europe. Agencies were established in Europe and in the Eastern States, and their representatives carried on propaganda wherever the field seemed ripe.

The coming of the railroads along with the invention of barbed wire, the mass production of windmills, the innovation of the sod house, and the acceptance of the steel plow and drill opened the way for the physical occupation of the plains. By 1890, the frontier was considered closed, and within another 20 years much of the basin achieved its highest settlement density. It took almost two centuries to settle the area east of the Great Plains, but less than 30 years to close the frontier within the basin.

With the influx of the farmer there developed a contest between him and the cattleman for the plains of the basin. On the one hand was the cattleman's social and economic way of life which had developed largely upon the plains themselves, but without cities and formal institutions, and without much formal civil government to support it. The cattleman relied mainly upon his own devices to solve his problems. When this failed, his recourse was to other ranchers through a stockman's association or similar organization.

On the other hand, the farmer entered the plains with the social and economic institutions which had developed in the two centuries of pioneering in the humid and forested East. The settler from the East had the traditions and support of the cities, institutions, and central government. It was inevitable that the latter won the contest. The significant factor is that by winning, the settlers from the humid areas imposed social and economic conditions upon the plains which were not well suited to their environment. A great deal of human misery and unwise land use was the result.

With the influx of the farmer into the plains, the regionalism of the West became apparent in national politics. This block has not always been unified, but it has been able to effectively trade its support to other political blocks for their support in such things as the mintage of silver, reclamation, and farm improvement programs for the plains.

Along with a sense of regionalism, the settlement of the plains also produced some of the rather basic political philosophy found in the basin. There has long been a feeling within the basin that the individual should be able to control his destiny to a large extent without interference from the rest of society or government. Yet, it is felt that society and government should provide assistance in reducing and mastering the problems which the individual faces. There has been a long mistrust of central government, but a very strong emphasis and pride in local governmental institutions. Unfortunately, local governments quite often cannot provide the assistance deemed necessary. Consequently, there has been a concurrent drive to reduce the influence of central government while agitating for more aid from the same institutions. It is a paradox much in evidence today.

In spite of the many problems, the lure of new land and the promotions of the railroads brought large numbers of settlers into the basin. In 1870, the population of Kansas was 364,399. In 1880, it was 996,096, an increase of *almost 300 percent within a* decade. The population of Nebraska increased more than 600,000 between 1880 and 1890. The Dakotas, a great expanse of almost uninhabited territory, was a sufficiently populous region within a decade to be admitted to the Union in 1889 as two states. In the short span of 50 years, 1870-1920, the population had increased 12 times in the seven plains States of the basin. There was a complete transition from the open range cattle and sheep grazing to farming and ranching.

A phase of the occupation of the plains of the basin was the dispossession of the Indians. Until 1861, the basin Indians were generally on friendly terms with the United States. Later, driven to desperation by the obvious fact that the end was near, the Indians made their last stand against the encroaching settlement by the whites. The Sioux uprising of 1862 was followed by that of the Cheyenne and other tribes in the 1860's, and the struggle culminated in the Sioux War of 1876. After this, the Indians were largely contained upon their reservations.

By 1900, most of the good arable land had been taken within the basin. The farmer's frontier had met and expropriated much of the rancher's cow country and now reached the mining country in the Rockies. Occupation and economic development were followed by admission to statehood; Colorado in 1876, North Dakota, South Dakota, and Montana in 1889, and Wyoming in 1890.

With the close of the frontier, many of the social and economic characteristics found within the basin today were in evidence. The humid eastern edge had become an extension of the Corn Belt and the plains were producing their basic products; livestock and small grains. In the mountains, the gold booms were over and agriculture had become firmly established. Irrigation had been introduced in the mountain valleys and along the mountain fronts with a water law based upon the doctrine of prior appropriation.

Many of the attitudes and beliefs that are much in evidence today, particularly in the rural areas and in the small towns, achieved their greatest growth during the settlement period. The ideas of individualism, the role of government in internal development projects, the basic distrust and agitation against the political and economic control of the East, the moral values concerning social order and goals, were all tied to the events and conditions of settlement within the basin.

Not all the mosaic of social and economic traits to be found within the basin were established during the settlement era for much of the character of the basin is uniquely the result of what followed. However, many of its basic characteristics have their roots in the manner by which the frontier was settled and are not recent events. Consequently, these traits probably will continue to be a part of the basin's character for some time to come and, therefore, will have a bearing upon many of the future actions of its people.

BOOM AND BUST

As the great influx of settlers into the basin progressed, the physical and economic problems they were to face became evident. Some of the physical hazards were apparent from the beginning, but when drought or grasshoppers drove a few of the settlers out of the basin, most stayed, and more came. The winter of 1885-86 resulted in a considerable exodus of settlers. So did the drought years of 1890-91, the grasshopper year of 1892, the panic year of 1893, and the drought period of 1894-96. With the rains of 1896 came a new wave of settlers into the basin. By 1899, the immigration boom was going strong and it reached its peak shortly after the turn of the century.

A number of innovations were developed during this time which helped the settlers cope with the climate and other natural hazards of the basin. From these innovations came the "dry farming" methods, new crop varieties, and new machinery which was better adapted to the basin's agriculture. However, such innovations had only a peripheral effect. By and large, the farmer came to accept the natural hazards as necessary evils or he acquired a sort of mystical hope that they would diminish as he settled the land.

The exploitive power of the railroads, the meat packers, the flour mills, and the credit institutions outside of the region were soon plainly evident to the settlers. The economic abuses by these interests soon became common practice in their dealings with the settler. The agriculturalist faced a situation that persists to the present. The costs of the goods and services needed for production and the prices received for the products of the land were set by forces outside of the basin and largely outside of the settlers' control.

In trying to cope with economic abuses, the settler of the basin early resorted to political action. From the end of the Civil War until well into the 20th century, parts of the basin were in an almost continuous condition of revolt. This revolt was waged primarily with political pressure through farmers' organizations and political parties as well as through various cooperative efforts in the field of business. The political activity was mainly directed at monetary deflation, railroad abuses, and monopoly practices.

While the prices of farm commodities declined in the late decades of the 19th century, those of manufactured products remained high or did not decline proportionately. Monopolies in meat packing and other processing industries were often able to hold the prices of farm commodities artificailly low while they profited by the high prices charged to consumers. The holders of patent monopolies on inventions such as barbed wire or well machinery were able to overcharge for their products. At the same time, the farmer felt that an undue share of the profits from his products were taken by the middleman and by the speculators on the grain exchanges. While the farmer did most of the heavy manual work, the eastern capitalists obtained most of the profits of his produce. "There are three great crops raised in Nebraska," said one of the farmers' papers in 1890. "One is a crop of corn, one a crop of freight rates, and one a crop of interest. One is produced by the farmers who by sweat and toil farm the land. The other two are produced by men who sit in their offices and behind their bank counters and farm the farmers." [1]

The 1930's represented the culmination of the boom and bust period. The depression in farm prices and recurring drought during the twenties had drained much of the economic strength of the basin. The results were high rates of borrowing and taxes with low income and reserves. Much of the basin's future income had been mortgaged. Then came the nationwide industrial and business depression which began in 1929. Next came the drought years of 1934, 1935, and 1937. With the drought was a further business recession in 1937. Cumulatively, these conditions all but bankrupted the basin's agriculture and brought about far reaching changes in its social and economic character.

[1] Farmers' Alliance, August 23, 1890. Quoted by Harold Faulkner, American Econimic History, P. 367.

The boom and bust period had one outstanding feature, radicalism. Radicalism was a feature of life throughout the basin and can be exemplified by listing some of the events that took place in Kansas during the 1890's. Kansas produced such people as "Sockless" Jerry Simpson, who became the leader of the Populist party in the 1890's, and Carrie Nation, the hatchet wielding champion of temperance who gained a nation-wide following. In the fall of 1890, the Farmers' Alliance got control of the House of Representatives. In 1892, the Democrats and the Populists joined hands in "an unholy alliance," and rose to political power. The climax came in 1896, when William Jennings Bryan won Kansas and much of the rest of the basin, but McKinley was elected president.

The radicalism of the basin appears to have been the result of an effort to adjust, through political action, to new conditions; a searching for the solution of problems where the old formulas failed and new ones were unknown. The political radicalism arose, at least partly, from the discontent of economic maladjustment. The settlers were unprepared for the physical hazards of the plains and the economic bondage that resulted.

THE PERIOD OF ADJUSTMENT

No other single event in the basin's history has had the deep, long lasting effects of its economic and social characteristics as the drought and economic depression of the 1930's. The hardship of earning a livelihood during this period was an object lesson which has never been forgotten by the people who lived through it.

Many of the basin's present community leaders are people who were able to survive the depression without going bankrupt and whose decisions, in both private and the public sectors, are greatly influenced by their experiences. In another 10 to 15 years they will probably be replaced by a younger generation, but for the present, the lingering fear that the conditions of the 1930's might reappear will continue to influence their attitudes. Perhaps the best way to characterize these people is that they tend to readily accept farming methods which help to reduce the risks they face; they tend not to gamble on new social and economic institutions if the old can be made to function for a while longer; they tend to have a conservative outlook on money matters; and they tend to insist upon maintaining rather large reserves.

The depression proved rather conclusively that the farming methods of the frontier were not suited to the environment of the basin, particularly the plains portion. The economic hardships of the depression undoubtedly speeded the acceptance of a large number of agricultural innovations which came into widespread use. During the thirties and early forties, the tractor almost completely replaced the horse as the farm power unit, the combine had made the threshing machine obsolete, and the introduction of several farm implements such as the disc plow made it feasible to apply stubble mulching and other dry land farming methods to large acreages. With the advent of modern farm machinery, the small acreage subsistence farm disappeared and the large commercial operation replaced it.

The depression was instrumental in bringing about changes in agricultural land use. During the settlement period, the land use emphasis had been on the exploitation of the soil resources. The dust storms of the 1930's proved that this was a situation the Nation could not afford. The result was a number of governmental programs which provided economic incentives and technical assistance for soil and water conservation. Perhaps more important, the agriculturalists came to realize that the maintenance of their soil resources was in their best interests.

The 1930's also made the Nation aware of the more serious economic and social problems within agriculture. For the first time in our history, the Federal Government initiated programs to directly control agricultural production, to deal with surpluses, to try to increase and stabilize the incomes of rural families, and to make rural life easier.

The total effect of the adoption of better farming methods, specialization, better land use, and the governmental programs was revolution in agriculture. Total production climbed dramatically, the efficiency of a single farmer increased several times, and many of the hardships of rural life disappeared. In fact, the electrification of the rural areas through the REA's, the advent of modern communications, and the improving of transportation have been of tremendous importance in allowing the rural people to partake of the goods and services enjoyed by the rest of society.

The 1930's also produced the start of the out-migration of the rural population. The basin counties as a whole probably had their greatest rural population about 1930, after which there has been a rather steady decline.

If the frontier was thought of as a safety valve for the eastern populations during the settlement period, the cities of the Nation can be thought of as being a safety valve for the rural population since the 1930's. The vast majority of the population which has left the basin's farms has migrated to the cities, both within the basin and outside of it. Few have become farmers in other areas. By and large, urban areas provided the out-migrants with a better standard of living and greater livelihood opportunities than the rural areas which they left.

There is not necessarily an inherent disadvantage in a decreasing population, but the sparse rural population within much of the basin has been, and is now, at a

The Dust Storms of the 1930's Demonstrated the Need for Soil and Water Conservation

point where it is too small to support many of the commonly accepted institutional patterns. The decreasing rural population has meant substantial losses in such services as churches, schools, and local government. Today many of the counties, particularly those within the plains, do not have sufficient populations to justify their existence as separate governmental units. Within many of the basin states, the township unit of government has never been functional, and of the township governments which were established, many can no longer perform their prescribed functions.

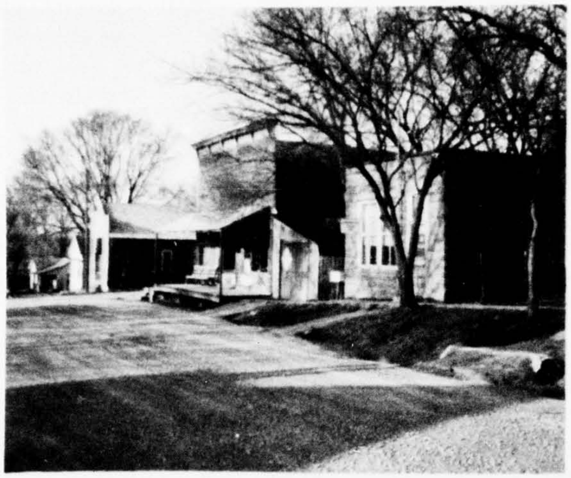
It is not easy to measure the extent of the social costs of space, but there is no doubt that they exist. Many of the costs occur in the form of subsidies made by local, State, and Federal Governments. Rural electrification and the R.F.D. are examples where other segments of the population provide a subsidy for their operation in the sparsely settled areas. Other social costs are not apparent at once but become evident at some later date. Inadequate schooling may not be apparent up until college entrance examinations are taken. The costs of maintaining a two-dwelling household for school purposes, one on the farm and the other in town, represents a higher social cost of space which a more densely settled area would not require. The lower quality of many services found in the rural areas also represents a social cost. These include inadequate facilities for religion, medical care, care for the aged, the mentally ill and retarded, prisoners, and juvenile offenders. All of these costs exist and are significant throughout the rural areas and even in some urban areas of the basin.

Related to the social costs caused by the sparse density of the rural areas are the costs related to the selectivity of out-migration. Migration from the basin appears to be highly age selective with the highest rate being in the young adult category. A number of reasons for the selectivity of the out-migration have been given, all of which are basically related to the fact that the metropolitan areas provide more desirable job opportunities than the rural areas. This is particularly true for the educated and highly trained.

One of the significant features of the growing numbers of the aged within the basin is that they tend to cluster in the smaller towns outside of the urban areas. Studies in Iowa indicate that there is a consistent increase in the proportion of those 65 and over as the size of the community decreases with the highest rate in the towns of 1,000 to 2,500. Similar trends appear to be true throughout the basin.

What of the people who are called upon to support the services needed in these areas? Today, the agriculturalists of the basin can be grouped into three very general categories. The first grouping contains those managers who are young family men, characterized by their great need for most of the social services and by a comparative small ability to pay. They are not willing, and quite often do not have the capacity, to pay for social services, even though their families are the most likely to benefit from them.

Managers in the second grouping are those that are in a older age group, have established themselves, and have been moderately successful through the years. They are not as likely to have young families, and if they do, they



Some Small Communities Will Find It Difficult To Survive

can generally afford to maintain a residence in a nearby town or city and quite often prefer this over paying for local services at their farm or ranch. More often than not, this manager is not very interested in maintaining a high level of social services in the rural areas.

The third general grouping of the rural managers is composed of people and institutions operating a "foreign owned" enterprise with few, if any, family obligations in the rural area. In this capacity, the general view is cutting the community, educational, and public service costs to a minimum.

Regardless of the extent of the future out-migration, there will be a group of people who will choose to remain in the rural areas for a number of reasons. Even though these people might treasure some of the attributes of rural living, they will still demand social services.

Can the rural areas adequately provide the kinds and the amount of services which will be demanded? At some point, the continuing shifts in the settlement patterns and the demands which will be imposed will require new patterns of social institutions; patterns that may be better able to cope with out-migration and the problems of high concentrations of dependent populations. In fact, much of the school district reorganization and the social programs initiated recently by State and Federal legislation are attempts to produce these new patterns.

Concomitant with the out-migration of the rural population has been a rather dramatic, but selective, growth in the urban areas. Only 42 percent of the population in the basin is currently classed as rural, compared to about 60 percent in 1940. Moreover, 65 percent of the urban population is concentrated in 11 metropolitan areas, with Denver, Omaha, and Kansas City accounting for three-fourths of the urban total. In 1960, only the Dakotas remained predominately rural with less than 50 percent of their populations living in urban places. However, they too will probably have a majority of their population in the urban areas by the next decennial census.

The growth of the urban areas has been great enough to more than offset the population losses of the rural areas and the basin states have had a growing population. However, their growth has been considerably less than it would be from the natural increase of population. Thus, a large percentage of the migrants has left the basin entirely. For example, the cities in South Dakota had a high growth rate between 1950 and 1960, but the population increase for the entire state was only 2 percent. Currently, some preliminary estimates indicate that both Wyoming and South Dakota might experience a net loss of population during the 1960-70 decade.

The urban growth has varied significantly between cities. The urban centers which have remained dependent upon providing services to agriculture have not tended to grow as fast as those with manufacturing bases. Further, the larger urban areas have tended to have higher growth rates than the smaller areas. The exceptions are the county seats or towns which have been able to retain other governmental functions, towns which have been able to develop tourist services, and towns which have become bedroom communities for larger urban neighbors. The cities with 5,000 to 10,000 populations have tended to remain relatively stable or grow slightly. The exceptions seem to be those with sizable governmental or educational institutions and those which have been able to attract a major industry such as a food processing plant. The cities over 10,000 have had the largest percentage of growth, particularly the large metropolitan centers. The growth rates indicate that the general service centers below 10,000 population have not fared too well as a rule.

The Standard Metropolitan Statistical Areas (SMSA's) have experienced very large and rather constant population increases since the 1930's. With the possible exception of Denver, these cities have continued to function as the gateways of commerce within the basin. In addition, their bases have been diversified with manufacturing, professional services, and governmental functions becoming important segments of their economies.

Denver is something of a special case. It has been able to increase its economic base by attracting regional offices of national corporations, research institutions, light industry which is not adversely affected by high transportation costs, Federal offices, and military installations. Consequently, the city is somewhat anomalous since its immediate hinterland, although large in areal extent, is very sparsely populated and contributes relatively little to the city's economy. The city is

primarily supported by capital and markets which are located outside of the basin.

One of the very striking characteristics of the basin is the absence of large urban populations on the plains. By far, the largest concentration of the urban population is along the eastern edge of the basin and there is a secondary concentration along the foot of the mountains in the west. Between these two there are virtually no urban places of consequence.

The demographic shifts have produced their share of problems. The large urban influx of population since the 1930's has certainly added to the social and economic problems found in most of the larger cities today. The relatively high social costs in the rural areas brought about because of low density populations are also incurred in the cities but attributed somewhat to high densities. These high-density populations have led to ghetto and slum conditions, air and water pollution, and general urban unrest stemming from high taxes which cannot keep pace with the increasing need for better housing, transportation systems, and, in general, a quality environment for living. As the cities proved to be the safety valve for the out-migration from rural areas, these areas may become the "safety valve" for population dispersion from the highly congested urban areas back to the rural areas. The type of situation described is national in character, and although many of the basin's metropolitan areas are faced with these problems, they are perhaps of lesser magnitude than those of other major cities of the Nation.

With its continuing economic and demographic problems, the basin is still in a period of adjustment. It is still in a process of trial and error in the quest to adjust to the physical and social environment.

ETHNIC GROUPS

The people who settled in the basin created a number of distinctive ethnic areas. Even though most of the settlement was by individual families rather than by groups of colonists, there was a tendency to cluster by nationality into cultural islands throughout the basin. Thus, there were numerous concentrations of settlers of German extraction in Missouri, Kansas, Nebraska, and Montana; Russians in the Dakotas, Colorado, and Nebraska; and Norwegians in North Dakota and Montana. In addition to the clustering of the people with similar national origins, there were concentrations of settlers from specific areas of the Nation. For example, the Ozark Plateaus were occupied primarily by settlers from the southern Appalachians; northwestern Missouri was occupied largely by people from the Upper South; some areas in Kansas were almost entirely settled by people from Ohio and Indiana; and other areas in Kansas, by settlers from New England. The remnants of these settlement concentrations are still discernable.

The predominate nationality groups that came to the basin were the Germans, Russians, Norwegians, Swedes, Czechs, Italians and the English, in about that numerical order. The Germans accounted for about 20 percent of the foreign born population. However, if all of the people with a British Isles background were grouped together, they would probably rival the Germans as the most numerous. In addition, there were several other nationalities but their numbers were relatively small. By and large, it is the descendants of these original settlers that occupy the basin today for later immigration has been relatively small.

The population shifts, easier communications and transportation, military service, and the general social mobility of the basin has tended to blur the boundaries of most of the cultural islands since the settlement days. Today, the majority of the population has fully assimilated and is approaching the cosmopolitan attitude exhibited in the more densely settled parts of the Nation. However, some of the ethnic clusters are still in evidence and are distinguishable by their kinship patterns, religious institutions, and the perpetuation of their national languages.

The Indians are basically a financially poor people, and are concentrated on 23 reservations. The Indian family annual income averages under $3,000 and is often below $1,000. The basic economy for the reservations has been ranching, some farming, and the leasing of land to whites. Traditionally, unemployment has been high on the reservations with rates of over 80 percent not uncommon, and rarely has the standard of living on reservations kept pace with the rest of the basin. And, in many instances, the standard of living on the reservations has not been rising as fast as in the rest of the basin's society. Consequently, some of the reservations are actually poorer in relation to the rest of society.

Public Housing Enables Indian Families To Move From Bare Shetler, As Shown On the Left, To More Adequate Housing

The Indian tribes of the basin have governmental institutions patterned on non-Indian principles but which have a peculiar autonomy set forth in treaties and subsequent legislation. Tribal and allotted Indian land, which is held in trust by the United States Government, is subject to tribal and Federal jurisdiction but not to State, county, or city jurisdiction. Thus, this land is neither subject to taxation or other assessment by the State and county governments, nor to State and county laws governing land use and development.

The peculiar autonomy of the Indian tribes enables them to appeal directly to the Congress for special legislation. This has been exercised on numerous occasions by various tribes, resulting in Federal legislation peculiar to only one specific tribe.

The Indians, with their differing economic and social characteristics, have to be considered as separate entities in the planning of resource developments. Perhaps the most serious mistake that could be made is to assume, consciously or not, that they have the same values, the same social philosophies, or the same outlooks on life as are commonly ascribed to the white communities within the basin.

THE CURRENT ECONOMY

Today, as in the past, agriculture is an important means of livelihood and the major producer of wealth within the basin. Few other major regions in the United States equal the Missouri Basin in the production of small grains and meat, the basin's specialties. Regularly, the basin produces a third or more of the Nation's wheat, 30 percent of its sorghum and barley, 20 percent of the corn, and 20 percent of the oats. In addition, the basin produces 40 percent of the rye in the United States, 30 percent of the sugar beets, and half of the flaxseed. In the livestock categories, the basin produces one-fourth of the Nation's red meat animals, cattle and calves, hogs, and sheep. This is accomplished on approximately 15 percent of the land area within the United States.

It is impossible to estimate how much of the total economy, either directly or indirectly, is dependent upon agriculture. Much of the noncommodity segment is made up of such things as machinery maintenance, feed grinding, fuel delivery, electric power supply, and similar services made directly to the farmer and dependent upon his income. In addition, the processing of food is by far the largest manufacturing segment within the basin. The large livestock markets and numerous meat packing plants of Sioux Falls, Sioux City, Omaha, St. Joseph, and Kansas City are basic to their economies. In fact, meat packing is the largest single food processing industry within the basin.

Even with the decreases in agricultural employment due to the inter-related rural out-migration and the mechanization of the farms, this sector still accounts for more jobs than does any of the other primary industries. Only the noncommodity (service and trades) sector employs more people. In contrast, mining industries afford work opportunities for only 3 percent of the labor force and manufacturing activities provide less than 8 percent of the jobs within the basin. Tables 4 and 5 show historical values of population, employment, and earnings for various segments of the basin's economy.

Table 4 – UNITED STATES AND BASIN EMPLOYMENT AND POPULATION

Population and Employment Group	1940 U. S.	1940 Basin	1950 U. S.	1950 Basin	1960 U. S.	1960 Basin
	(Thousand)					
Population	131,954	6,772	151,234	7,063	176,291	7,931
Employment, Total	45,375	2,236	57,475	2,716	66,373	2,985
Agriculture	8,670	792	7,148	741	4,528	512
Manufacturing	10,755	190	14,818	288	18,229	411
Other Commodity	3,033	120	4,453	203	4,653	216
Noncommodity	22,917	1,134	31,056	1,484	38,963	1,846
Employment/Population in Percent	35.0	33.0	38.0	38.5	37.6	37.6
Basin/U.S. Employment in Percent	4.9		4.7		4.5	

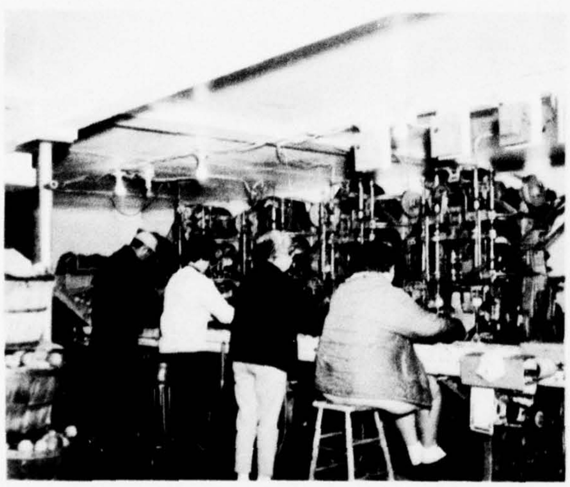
Table 5 – EARNINGS PER EMPLOYEE BY MAJOR EMPLOYMENT GROUP NATION AND MISSOURI BASIN

Employment Group	1940 Nation	1940 Basin	1950 Nation	1950 Basin	1960 Nation	1960 Basin
	(Current Dollars)					
Agriculture	646	794	2,241	3,111	3,158	3,181
Manufacturing	1,517	1,405	3,527	3,342	5,038	4,445
Other Commodity	1,256	1,019	3,212	2,894	5,309	5,515
Noncommodity	1,620	1,381	3,167	2,924	4,456	4,054

The total value of farm products sold in the basin was approximately 4.6 billion dollars in 1959 and 5.1 billion in 1964, with the average value per farm being $13,444 in the latter year. In 1964, livestock and livestock products accounted for 70.6 percent of the total sales from farms. The sale of livestock and livestock products was greater than crop sales in all but the Upper Missouri Subbasin. However, substantial amounts of the grains grown within the basin are fed to livestock and marketed as a part of the animal.

The manufacturing segment of the basin's economy has been enjoying rapid growth during the last two decades. Unfortunately, most of the manufacturing has remained in the metropolitan areas with Denver, Kansas City, Omaha, and Sioux City accounting for 70 percent or more of the total manufacturing within the basin.

For the cities of 10,000 to 50,000 population, there has been some progress in attracting manufacturing in recent years. The trend that has helped most has been the decentralization in the food processing industries. Industries such as meat packing are becoming more oriented to smaller plants located closer to the sources of their raw materials. Also, there has been a small influx of light industry, such as machinery fabrication and electronics. Even though the growth of manufacturing has been good in some of the medium sized cities, the growth in smaller cities has been rather sporadic. The plains portion of the basin has been particularly slow in attracting new industries.



Food Processing Plants Are Important Industries in the Towns of the Basin

The "other commodity" segment of the economy (mining and contract construction) has not been growing at a particularly fast pace. Within the mining segment, the fuels industries experienced the slowest employment growth while enjoying substantial production increases. However, the proven petroleum and coal reserves probably represent the greatest mineral potential in the basin.

Contractual construction is tied to the general welfare of the other economic segments and to their growth. Again, the large metropolitan areas have dominated this segment. This is to be expected, for they have had the greatest population and industrial growth rates within the basin.

The most rapidly expanding sector of the economy and the one which accounts for the largest proportion of employment, both nationally and in the basin, is the noncommodity-producing group. In 1940, over 1.1 million were employed in this segment, which amounted to just over half of the total employment in all segments of the economy. By 1960, the noncommodity-producing employment had increased to 1.8 million, accounting for 61.8 percent of the total employment in the basin.

While the noncommodity sector contains some industries which are basic to many local economies and are generative in that they support local employment, the majority of employment in this sector is of the trade or service variety. As such, it is typically composed of the labor intensive industries which depend largely upon the wealth produced by the more basic segments of the economy such as agriculture and manufacturing. Only when the noncommodity industries are supported by money created outside of the basin do they add to the basin's total economy. At other times, they simply represent the re-expenditure of wealth created by some other industry within the basin. Thus, they are in large part dependent upon the economic health of the rest of the basin's economy. These are the industries that predominate in the economic bases of the smaller cities and towns. The small urban areas within the plains are almost entirely dependent upon this segment of the economy.

Table 6 gives the breakdown of the noncommodity employment categories. As can be seen, the trade and service categories predominate. Even though the government and military category has had the largest percentage increase, the trade category has matched it in terms of the increase in workers, with 100,000 in the 1950-60 decade. In the same time period, the service category has increased by some 163,500 workers. One of the major reasons for the increase in the trades and services has been a boom in the tourist industry during the last few years.

There has been a widespread interest within the basin in attracting the tourist dollar. In some favored locations tourism is the primary industry and in many other areas of the basin it is second only to agriculture. Tourism has become a particularly important source of income for many of the small towns and cities. Consequently, there have been a number of conserted efforts to develop the scenic, hunting, and fishing potentials and to provide the services needed by the tourist. Throughout the basin,

Table 6 – NONCOMMODITY PRODUCING EMPLOYMENT, BROAD CATEGORIES
MISSOURI BASIN: 1940, 1950, AND 1960

Category	1940	1950	1960	Percent Growth 1940-1960
Government & Armed Forces	94,892	157,343	258,376	172.3%
Trade, Finance & Real Estate	452,690	610,236	710,340	56.9
Professional & Personal Service	414,631	470,248	633,816	52.9
Transportation & Communication	171,945	246,522	243,316	41.5
Noncommodity Missouri Basin	1,134,158	1,484,349	1,845,848	62.8

Tourism Continues To Grow In Economic Importance

this industry has probably the most potential for future growth and it is expected to become increasingly important.

However, the dependence of the majority of the basin's workers on the noncommodity-producing industries has not been a total blessing. Historically, their wages have been well below the Nation's average. Thus, the growth of this segment of the basin's economy has not had as great an impact as the numbers employed would indicate. The lower salaries paid means that it cannot effectively compete with other areas of the Nation for the trained worker, either in manufacturing or in the trades and services. Consequently, many of the best do not stay in the basin, but migrate to other areas. This is particularly true for the highly skilled and college educated.

Both the average earnings and the per capita incomes within the basin have been consistently below the national levels. Only a few of the larger cities have been able to maintain income levels above or near the national average. The most rural of the subbasins tend to have the lowest employee earnings and per capita incomes of the basin. On the other end of the scale, the more urbanized subbasins tend to have the higher earnings and per capita

income. This is not surprising since the more highly skilled industrial jobs and the better paying professional services are located in the larger cities but are rarely found in the rural areas.

PROJECTIONS OF THE FUTURE ECONOMY

Based principally on historic trends, projections of the economy to the year 2020 have been made for planning purposes. Tables 7 and 8 summarize projected economic parameters, such as population, employment, income, and earnings.

Table 7 – PROJECTIONS OF POPULATION AND EMPLOYMENT MISSOURI BASIN: 1980, 2000, AND 2020

Population and Employment Group	1980	2000	2020
		(Thousand)	
Population	10,433	14,345	20,060
Employment	4,074	5,591	7,826
Agriculture	336	272	249
Manufacturing	652	879	1,202
Other Commodity	306	416	578
Noncommodity	2,779	4,024	5,797
Employment in Percent of Population	39.1	39.0	39.0

It appears that agriculture will continue to dominate the basin's economy well into the future. Manufacturing and any growth in heavy industry the basin experiences will continue to be concentrated in the metropolitan areas. Minerals and timber will be important economic bases only in a few localities where these resources occur. There is not too much likelihood that the basin will gain significant employment from the refining of petroleum or metals outside of the large urban areas. With the expected continuation of out-migration from the rural areas, the small towns will continue to lose their service functions to larger neighbors unless they are able to diversify into such things as tourism and light industry. In short, it appears that the trends since the 1930's will continue in the future.

Table 8 – PROJECTED PER CAPITA PERSONAL INCOME EXPRESSED AS A PERCENT OF THE NATION

Subbasin and SMSA	1980	2000	2020
		(Nation = 100)	
National Per Capita Personal Income (1954 Dollars)	$3,200	$5,000	$7,750
Upper Missouri	97.7	97.5	100.2
Great Falls	(97.6)	(97.0)	(100.7)
Yellowstone	97.7	97.4	97.2
Billings	(103.8)	(102.6)	(99.6)
Western Dakota	87.5	90.7	100.4
Eastern Dakota	84.3	86.3	91.0
Sioux Falls	(97.8)	(98.6)	(100.3)
Platte-Niobrara	103.4	100.0	98.8
Denver	(110.2)	(102.6)	(99.4)
Lincoln	(100.3)	(99.7)	(100.0)
Middle Missouri	98.6	97.9	98.4
Omaha	(110.9)	(103.6)	(102.0)
Sioux City	(103.0)	(101.0)	(99.8)
St. Joseph	(103.1)	(101.1)	(97.9)
Kansas	95.8	96.0	95.5
Topeka	(108.6)	(102.4)	(99.6)
Lower Missouri	95.1	96.1	96.8
Kansas City	(107.9)	(105.0)	(102.7)
Springfield	(96.2)	(96.7)	(98.2)

There is a growing awareness within the basin that a more efficient utilization of the water and related land resources may help in stabilizing the population shifts which have been occurring. Water resources development is not the entire solution to the demographic and economic problems of the basin, but it is felt that it can be a significant part of their solution.

CHAPTER 4

EXISTING SITUATION

Since planning for the future must be based first on a clear understanding of the prevailing situation, the plan for development of land and water resources to meet future requirements was formulated on a foundation consisting of inventories of the available land and water resources; the extent of current development and use of these resources; the problems which remain unresolved; and the prevailing legal and institutional factors which have governed the development and management of water and land resources. However, not all aspects of the prevailing situation are equally clear, partially because of limitations of available data and partially because water consistently refuses to recognize the behavior characteristics and institutional arrangements imposed by man.

LEGAL AND INSTITUTIONAL CONSIDERATIONS

The current status of land and water resources development in the Missouri River Basin has limited significance to plan formulation without some understanding of the legal and institutional considerations which have governed their development and use. The legal factors include Federal statutes, State laws, particularly water laws, and the State enabling legislation which has fostered formation of flood control districts, irrigation districts, watershed districts, rural water districts, water conservancy districts, sanitary districts, and others. The institutional considerations include the functions and policies of State and Federal agencies involved in planning, developing, and managing land and water resources, and the functions of subdivisions of local government and individuals in their relationships with the States and the Federal agencies in the development and use of water and related land resources.

WATER LAW

Water law and the water rights of individuals, subdivisions of local government, and corporate entities are the fundamental legal basis for water resource development and use, and, because of the essential relationship of land and water for productive use, water law has had a significant influence on the use of the basin's land resources.

Within the Missouri River Basin, State water laws are based on two distinct doctrines, the common law doctrine of riparian rights and the doctrine of prior appropriation. Stated briefly, under riparian doctrine, the owner of land contiguous to a natural stream or natural lake may use the waters in such quantities as he wishes, so long as his use does not appreciably diminish the flow or impair the quality of the water for downstream use. The riparian owner's right is subject to the same right enjoyed by others similarly located. His right is not acquired by actual use of water, nor is it impaired by failure to use it.

Under the doctrine of prior appropriation, beneficial use is the basis, the measure, and the limit of the water right. The first beneficial appropriation in time enjoys the prior right. The right is perfected only by actual beneficial use and may be lost if that use is discontinued or abandoned. The appropriated water may be used either on lands contiguous to the stream or on lands distant from the stream. In practice, the prior appropriation doctrine also defines priorities of beneficial use, with domestic and agricultural uses generally having priority over other uses.

In the Missouri River Basin, two states (Minnesota and Missouri) continue to recognize the riparian doctrine exclusively, while three states (Colorado, Montana, and Wyoming) have based their water laws solely on the doctrine of prior appropriation. In the states of Kansas, Nebraska, North and South Dakota, and Iowa, state water laws rely heavily on the appropriation doctrine, but recognize the riparian doctrine in varying degrees. The water laws of Iowa make many uses of water in the State subject to administrative regulation regarding diversion, storage, or withdrawal. This regulation is applied under a water permit for specified periods of time not exceeding 10 years, after which the rights for use are subject to review and reissuance by the State. It is noteworthy that Minnesota and Missouri, which utilize the riparian doctrine exclusively, and Iowa, which utilizes a permit system, are situated in the more humid areas of the basin where precipitation is more adequate and surface-water supplies are more plentiful and dependable. However,

substantial portions of the seven other states have a semi-arid or arid climate with limited and erratic precipitation and corresponding limitations on the total and seasonal availability of surface-water supplies. Thus, the adoption of the appropriation doctrine in the states with historically deficient water supplies resulted from practical necessity, and water resources development in these states would have been impossible, or at least chaotic, without water laws based on this doctrine.

Of the seven states with water laws based on the appropriation doctrine, six have established an agency of the state to administer water rights. These agencies are responsible for receiving and processing applications or filings for new water rights and for policing the streams to prevent violations of established water rights. In the remaining state, Montana, surface water rights are administered by the District Courts.

In six states of the Missouri Basin there may exist, along with rights under State laws, many Indian water rights read from the treaties and agreements between Indian tribes and the United States which have been approved by the Congress or formalized by Executive Orders. It has been interpreted that Indian water rights normally have a priority as of the date on which the Indian reservation was established and maintain their validity, even though unexercised. Such rights can be quantified by fixing the amount of water needed to serve the purposes for which the Indian Reservation was established. Thus, if the purpose of the reservation was to promote an agricultural economy, as generally has been the case, the quantity of water reserved would be the amount needed to serve practically the irrigable acreage on the Indian Reservation. Use of Indian water rights for non-irrigation purposes has not been judicially questioned or ruled upon. Some Missouri River Basin States are not in agreement with the Indian water rights position as outlined, and believe further legal clarification of these rights is required. This matter is discussed further in chapter 9.

Interstate Water Compacts and Court Adjudications

The apportionment of the water resources of streams which cross State boundaries is achieved by interstate compacts subject to ratification by the Congress, or by litigation seeking court adjudication to apportion the water resources of the stream among the States involved. With respect to the water resources of the Missouri River Basin, the States of Colorado and Wyoming are each parties to two interstate compacts with bordering states, and each has had other interstate water resources apportioned by litigation and court adjudication. The State of Nebraska is party to three interstate compacts and one settlement by court adjudication. The States of Kansas, Montana, and North and South Dakota are parties to one interstate compact each with various bordering states. A compact on the Big Blue River is under negotiation by Nebraska and Kansas and one other compact involving Nebraska and South Dakota awaits congressional ratification. All of the existing interstate compacts and court adjudicated apportionments concern allocations for direct diversion or storage of surface waters. Table 9 summarizes the existing and pending interstate compacts and court adjudications in the basin.

FEDERAL LEGISLATION

Over the years, numerous laws have been enacted by the Congress which affect water and related land resources. These are enumerated in the appendix, "Laws, Policies, and Administration Related to Water Resources Development." This legislation has resulted in Federal involvement in the water resources field ranging from data collection and research to planning, construction, and management of projects and programs. The underlying basis of Federal legislation and investments has been to promote the national interest by participation in the development and management of natural resources; to foster economic stability by assistance in prevention and mitigation of natural disasters; and to encourage and assist in solutions of problems relating to water and land resources which involve the national interest by reason of their widespread scope and serious impacts on the health and welfare of the people.

Within the overall scope of the history of basin development, three aspects of Federal legislation merit specific mention, because of their particular significance to the water and land resource problems of the basin. These are: (1) The Reclamation Act of 1902; (2) The Flood Control Act of 1936; and (3) The Soil Conservation Act of 1935 and the Watershed Protection and Flood Prevention Act of 1954.

The Reclamation Act of 1902 authorized the Secretary of the Interior to build water diversion and impoundment facilities to provide irrigation water for public and private lands in the 17 states west of the 98th Meridian. The fundamental purpose of the act was to reclaim and foster settlement on undeveloped lands of the Western States, with limitations on the size of individually owned acreage furnished irrigation water. The Reclamation Act has since been amended and expanded to permit water resources development for other beneficial purposes.

The Flood Control Act of 1936 established the policy that flood control was in the national interest, and provided the basis for initiating a program for control of the periodic devastation of the basin caused by widespread floods. Subsequent flood control acts amended the 1936 Act to authorize Federal participation in more comprehensive water resources development.

Table 9 — EXISTING INTERSTATE WATER COMPACTS AND ADJUDICATIONS
MISSOURI BASIN

Designation	States & Ratification	Date	Congressional Ratification	General Principle of Compact
EXISTING INTERSTATE COMPACTS				
Belle Fourche River Compact	South Dakota Wyoming	1943 1943	1944	Established apportionment of direct diversion and storage.
Republican River Compact	Colorado Kansas Nebraska	1943 1943 1943	1943	The object was to agree upon the division of the waters of this river. Each state was allocated a given quantity in acre-feet for consumptive use.
South Platte River Compact	Colorado Nebraska	1925 1926	1926	Apportions the waters of this stream to the two states based on maintaining stateline flow during specific periods of time.
Yellowstone River Compact	Montana North Dakota Wyoming	1951 1951 1951	1951	Allocation of unused and unappropriated waters for storage and direct diversions.
Upper Niobrara River Compact	Nebraska Wyoming	1963 1963	1969	Allocation of unused and unappropriated waters for storage and direct diversions.
INTERSTATE ADJUDICATIONS LITIGATION	**States and Dates**			**General Principle of Decree**
Laramie River	Wyo. vs Colo. 1922 1932 1936 1940 1957			Original decree has been amended and modified. Allocated quantity of water to be consumed within basin and limits a quantity which may be used within the basin or directed outside basin in Colorado.
North Platte River	Nebr. vs Wyo. 1945 & Colo. 1953			Decree limits Colorado right to consume water for irrigation & storage for irrigation & right to divert outside of basin. Further it limits Wyoming diverting or storing water for irrigation. Provides for allocating natural flow between Nebraska & Wyoming.
INTERSTATE COMPACTS UNDER NEGOTIATION	**States Involved**			**Status**
Big Blue River	Kansas-Nebraska			Under negotiation.
Cheyenne River	S. Dak. & Wyo.			Ratified by South Dakota only.
Lower Niobrara and Ponca Creek	Nebraska-S. Dak.			Ratified by both states; Pending in Congress.

The Soil Conservation Act of 1935 (PL-46), as amended, provides for a national conservation program to achieve the proper use, development, and sustaining management of soil, water, and related resources. Technical assistance is provided for individual farmers and ranchers, local groups, and units of government.

The Watershed Protection and Flood Prevention Act of 1954 (PL-566), as amended, provides technical assistance and financial cost-sharing on a project basis to upstream watersheds of less than 250,000 acres. The Act provides for the investigation, plan formulation, and installation of project works of improvement for flood prevention (including structures and land-treatment measures), watershed protection, and agricultural water management. Also provided for are the inclusion of such purposes as recreation, fish and wildlife, municipal and industrial use, irrigation, and low-flow augmentation in multiple-purpose floodwater detention reservoirs of less than 25,000 acre-feet capacity. Current policies prohibit assistance to projects with a primary purpose of bringing new lands into agricultural production.

Other Federal legislation of particular importance to water resources development in the basin includes the Fish and Wildlife Coordination Act of 1934 (as amended), the Water Supply Act of 1958, the Federal Water Pollution Control Act of 1956 and subsequent amendments, the Federal Water Project Recreation Act of 1965, and the Water Resources Planning Act of 1965. Respectively, these Acts have established Federal policy concerning: (1) preservation and enhancement of fish and wildlife resources in conjunction with Federal participation in water resources developments; (2) provision of storage capacity for municipal and industrial water supply and low-flow augmentation in federally constructed reservoirs; (3) preservation of water quality;

(4) Federal participation in water-based outdoor recreation, including fish and wildlife; and (5) Federal participation in comprehensive river-basin planning for water and related land resources development, conservation, and management.

Senate Document 97, 87th Congress, 2d Session, represents a response to a request by the President of the United States in 1961 to the Secretaries of the Army, Interior, Agriculture, and Health, Education and Welfare to establish uniform policies and procedures for formulating plans for use and development of water and related land resources. Thus, it is founded on the policies established by Federal legislation, but prescribes uniform interpretation of this legislation by the Federal Departments concerned with the development of water and land resources, and by the Bureau of the Budget in its review of the recommendations of these Federal Departments. Formally, it is a joint statement by the Secretaries of the above-named Federal Departments, entitled: "Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources" which was submitted to the President for approval. In May 1962, the President approved the statement for application by the Federal Departments concerned, and although not formally approved by the Senate, it was published as a Senate document. These procedures and standards are recognized in water resources planning by all agencies, but full implementation of plans formulated in accordance with the concepts in the document has not been achieved. The importance of this statement to comprehensive basin planning is illustrated by the fundamental policy expressed that ". . the basic objective in the formulation of plans is to provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs."

A general summation of the significance of Federal law to water resources planning would be incomplete without some mention of a significant aspect of the 1944 Flood Control Act. Section 1(b) of the Act, applicable to all western basins including the Missouri Basin, states:

> "The use for navigation, in connection with the operation and maintenance of such works herein authorized, of waters arising in States lying wholly or partly west of the 98th Meridian shall be only such use as does not conflict with any beneficial consumptive use, present or future, in States lying wholly or partly west of the 98th Meridian, of such waters for domestic, municipal, stock water, irrigation, mining, or industrial purposes."

Since enactment, Section 1(b), also referred to as the O'Mahoney-Millikin amendment, has been the subject of controversy and uncertainty regarding its effects and implications on navigation. The issue relates to the precedent of Congressional legislation and Supreme Court decisions that, on navigable streams, the primary objectives of improvements must be navigation and flood control, and that other beneficial uses, except for the improvement of public lands, were subordinate to these primary objectives. However, the supporters of the amendment sought an expression of Congressional policy which would limit the authority of the Federal Government in the western basins to utilize for navigation such water resources as may be necessary for current or future domestic, agricultural, and municipal and industrial uses.

Institutional Arrangements

It has been a characteristic policy of Federal legislation on water resources development that the planning, construction, and operation of improvements be carried out "in cooperation with states, their political subdivisions, and localities thereof." Moreover the various cost-sharing requirements specified in Federal legislation for water resources development have emphasized the partnership role of State-Local-Federal relationships in the area of water resources. The States have fostered cooperation by adjusting their institutional policies to changing requirements and by enacting legislation to provide the cooperation and cost-sharing essential to cooperative planning and development of water resources. A number of institutions at all levels of government operate within the legal and policy framework thus developed.

At the State level, various institutions ranging from organizations at State level to political entities formed under State laws have varying responsibilities and legal powers in the field of water resources development and management. As mentioned above, State legislation provides one means for adjusting institutional arrangements to meet the needs prevailing at any specific time.

While there are a number of Federal agencies involved in water resources development, three have primary responsibilities for planning, construction, and/or operating federally financed water resources programs and projects. These are the Corps of Engineers, the Bureau of Reclamation, and the Soil Conservation Service. While their roles are similar in the general context of planning, construction, and/or operation, the distinctions between them have been in the historic specialization of roles assigned by Federal legislation and in the agency expertise which has developed as a result of these historic roles. These roles have, to some extent, inhibited complete comprehensive planning. In carrying out their responsibilities, each agency attempts to overcome this handicap through close cooperation with the other Federal agencies and with State water agencies, counties, municipalities, and the conservancy, irrigation, watershed, drainage, flood control, and other districts

organized under State laws, and with those other Federal agencies which have authorized roles in water and land resources planning. Table 10 summarizes the responsibilities of the various Federal agencies engaged in the field of water and related land resource development. Similar information on State institutions may be found in the appendix, "Laws, Policies, and Administration Related to Water Resources Development".

Table 10 – WATER-RELATED RESPONSIBILITIES OF FEDERAL AGENCIES

Department or Agency	Functions Relating to Water Resources
DEPARTMENT OF AGRICULTURE	
Agricultural Stabilization and Conservation Service	Financial assistance for conservation work on farms and ranches and in disaster areas.
Farmers Home Administration	Financial and technical assistance for rural water supply and sewerage.
Forest Service	Watershed protection on forest and range lands, recreation, research, and financial assistance.
Soil Conservation Service	Watershed protection, irrigation, water supply, recreation, flood control. Technical and financial assistance for conservation work, snow and soil surveys.
DEPARTMENT OF COMMERCE	
Bureau of Standards	Hydraulics Research
Environmental Science Services Administration	Hydrometeorological investigations, weather modification research, weather forecasting, flood stage forecasting.
DEPARTMENT OF DEFENSE	
Corps of Engineers, Civil Functions	Navigation, flood control, municipal and industrial water supply, recreation, hydroelectric power, multiple-purpose water resources projects, streambank stabilization.
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE	
U. S. Public Health Service	Health aspects and water quality.
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT	
Land and Facilities Development Administration	Loans and grants for water and sewerage projects.
Office of Planning Standards and Coordination	Loans and grants for public works planning.
DEPARTMENT OF THE INTERIOR	
Office of Water Resources Research	Grants and contracts for water resources research.
Office of Saline Water	Research and development on desalinization.
United States Fish and Wildlife Service	Conservation of fish and wildlife.
Bureau of Sport Fisheries and Wildlife	Conservation of sport fisheries and wildlife.
Bureau of Commercial Fisheries	Conservation of commercial fisheries.
Bureau of Indian Affairs	Water and related land resource projects on Indian reservations.
United States Geological Survey	Collection of basic data on water resources.
Bureau of Land Management	Water and land resources management on public lands.
Bureau of Mines	Analysis of mineral industry water needs.
National Park Service	Preservation and management of the national park system.
Bureau of Outdoor Recreation	Outdoor water and land-based recreation research, plans, coordination, grants, Federal acquisitions, and policies.
Bureau of Reclamation	Irrigation, municipal and industrial water supply, hydroelectric power, multiple-purpose water resource projects.
Federal Water Quality Administration	Water quality planning and management, pollution abatement, research and grants and enforcement of interstate water quality standards.
FEDERAL POWER COMMISSION	Hydroelectric power studies and licensing.

NOTE: Above cited agencies reflect status of 1968. Departmental re-organizations were effected in 1970.

Within the institutional framework outlined, water and related land resources plans are developed, Congressional authorizations sought, and contractual arrangements for financing, operating, and managing the improvements are completed. The cost-sharing criteria defined in chapter 6 are based on the requirements provided by existing Federal laws and policies.

The preceding discussion has centered on the cooperative relationships between the Federal Government and the States and their political subdivisions. These relationships evolved during periods of less complex water problems by progressive refinements of the roles of the Federal Government and the States and their political subdivisions in development and management of water resources. As water problems become more complex, the indifferences of water to political boundaries will compel formation of regional institutions to promote more comprehensive development and use of water resources. Currently, the regional institutions which function in the Missouri River Basin are the Missouri Basin Inter-Agency Commitee and the Missouri River States Committee. The membership of the former consists of representatives of the eight Federal Departments - Agriculture, Army, Commerce, Health, Education and Welfare, Interior, Labor, Transportation, and the Federal Power Commission - and the Governors of the 10 basin States. The membership of the latter consists of one or more representatives of each of the 10 basin States.

These regional committees function primarily as coordinating institutions by providing a forum for discussing policies and programs from a regional viewpoint. They have neither a staff for technical planning at the regional level nor legal powers to authorize or finance construction and operation of water resources developments. They rely on State agencies and the agencies of the Federal Department members of the Committees for technical assistance.

CURRENT STATUS OF DEVELOPMENT

Water resource developmental and management programs in the Missouri River Basin began over 100 years ago. Significant periods of development were prior to 1910 and since 1949, the latter being the period during which the Pick-Sloan Missouri Basin Program was being implemented. The nature of the institutional framework has been modified significantly through evolution of the legal and institutional systems discussed above. The earlier aspects of water resources development were oriented to single-purpose improvements to meet specific requirements without substantial regard for other potential functions. However, an expanding economy, technological improvements, and human aspirations beyond the limits of basic subsistence have imposed greater demands on water and land resources, and have created a shift of emphasis from single-purpose to multiple-purpose programs.

Although the earlier developments were constructed and financed primarily by private groups and political subdivisions, the increasing complexity and higher costs of water resources development soon began to exceed the legal powers and financial resources of these interests. This led to progressive enactment of a body of Federal legislation which has permitted greater utilization of the technical and financial resources of the Federal Government to plan, construct, and where appropriate, to operate water resources developments in cooperation with the States and their political subdivisions. Nevertheless, a major portion of the existing water resources development represents the efforts and resources of State, local, and private interests.

The identification of the scope of the existing status of water resources development in the basin, which is summarized in the following paragraphs, is limited to the major features of the program, and is discussed in terms of the entire basin. A summary of the existing status of water and land resources development in each subbasin and the relationships to available resources and existing problems and needs in the subbasin is included in chapter 7. For the purposes of this study, the existing status of development is defined as consisting of those projects which were either completed or under construction in 1965.

The summary of existing water and land resources development in the basin includes storage reservoirs for various purposes; and watershed protection measures, irrigation works, flood and erosion control measures, water supply systems, electric power facilities, waste treatment facilities, outdoor recreation and fish and wildlife enhancement programs, and navigation improvements.

Reservoirs

In 1965 the Missouri Basin contained 107 major reservoirs and 1,387 reservoirs with individual storage capacities of less than 25,000 acre-feet which were either completed or under construction. In aggregate, these reservoirs provide a total of over 112 million acre-feet of storage capacity. The investment cost for this storage capacity was over $3 billion. Almost 99 percent of the total storage capacity serves multiple-purpose functions. Table 11 summarizes the basin's reservoir systems.

Land Conservation and Management

With the exception of most of the irrigation developments and the larger-scale flood-control improvements, which are discussed later, the basin's water and related land resource improvements for agriculture have been primarily installed through the small watershed protection and flood prevention projects and rural conservation and development projects. The need to preserve the agricultural productivity of the basin became strikingly evident during the extensive drought of the 1930's and was reinforced by continuing evidence of losses of topsoil and severe erosion of productive lands by floods and vegetative denudement. These measures

One of the Missouri River Dams and Reservoirs Which Serve Many Beneficial Purposes

Table 11 – EXISTING STORAGE RESERVOIRS
MISSOURI BASIN

Purposes Served	Major Reservoirs No.	Major Reservoirs Storage	Other Reservoirs No.	Other Reservoirs Storage
		(1,000 AF)		(1,000 AF)
All–Missouri Basin	107[1]	110,567	1,387[2]	1,636
Flood Control	(53)		(1,285)	
Water Supply	(30)		(11)	
Irrigation	(77)		(39)	
Power	(39)		(12)	
Fish and Wildlife	(50)		(4)	
Recreation	(52)		(4)	
Navigation	(10)			
Quality Control	(5)			

[1]The sum of the figures in parentheses is greater than the total due to joint use.
[2]Individual storage capacities of less than 25,000 acre-feet.

include land treatment and management by maintaining vegetative cover, terracing, grade stabilization, flood water detention structures, and farm ponds. In addition to water and land resource improvements on agricultural lands, similar improvements and conservation practices have been implemented on just under 7 million acres of nonagricultural lands, or about 84 percent of the total in need of such practices. Table 12 summarizes the extent of the development and management program.

Irrigation

Irrigation is the single largest user of water in the basin. Currently, about 7.4 million acres of irrigated land (consisting of 6.9 million acres of cropland and 0.5 million acres of pasture) require an annual farm delivery in excess of 14 million acre-feet of water. About 5,800,000 acres have been developed for service by group irrigation systems, of which nearly 138,000 acres are on Indian lands. These group developments have an aggregate reservoir storage capacity of nearly 9 million acre-feet, often used for multi-purposes, and about 42,000 miles of group-delivery canals. About 45 percent of the storage capacity for group irrigation systems is in reservoirs constructed by irrigation districts, water companies, or the States, with Federal construction accounting for the remaining storage capacity. About 75 percent (32,000 miles) of the group-delivery canals was constructed by non-Federal interests and 25 percent (10,000 miles) was constructed by Federal agencies. Of a total of 120,000 acres of irrigated Indian lands, over 61,000 acres are served from 52,600 acre-feet of storage capacity and 675 miles of group-delivery canals.

Table 12 – LAND CONSERVATION, WATERSHED IMPROVEMENTS, AND MANAGEMENT PROGRAMS, MISSOURI BASIN

Type of Measure	Purpose	Extent of Development
Land Conservation	Soil and plant protection, and stability improvement	
Private land		110 million acres
Public land		29 million acres
Ponds for Livestock Water	Livestock water, recreation, and grade stabilization	
Private land		305,000 ponds
Public land		9,000 ponds
Upstream Watershed Improvements	Flood damage reduction, grade stabilization, recreation, irrigation, etc.	118 projects 1,264 reservoirs 542 miles of channel improvement 1,885 grade structures

A Total Conservation Program Has Been Implemented on this Basin Farm

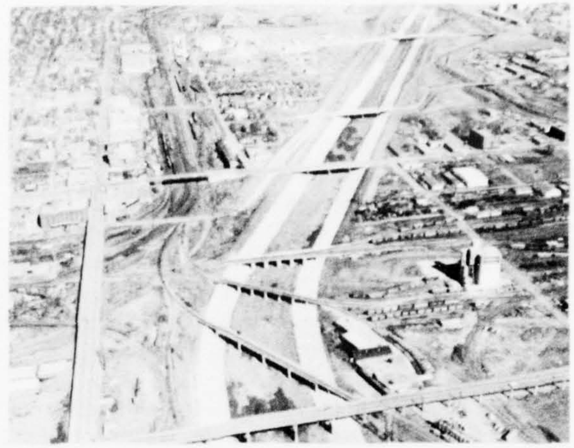
Sprinkler Irrigation Is Increasing In Importance

In some instances, federally constructed irrigation systems also provide supplemental water to non-federally constructed irrigation systems. It should be noted also that the group irrigation systems are unable to provide adequate water supply to portions of the 5.8 million acres each year.

Flood and Erosion Control

Flood control and flood damage prevention in the basin are achieved by measures involving multiple-purpose and single-purpose storage reservoirs, channel improvements and levees, and upstream watershed projects. By 1965, 228 federally constructed projects involving direct flood control measures were completed or under construction in the basin. These included 53 major reservoirs, 57 channel and levee projects, and 118 upstream watershed projects. Throughout the basin, the channel and levee projects involve approximately 1,200 miles of levee construction and about 800 miles of channel improvements. Upstream watershed projects involve watersheds totaling 149 million acres with 3,149 flood-prevention and grade-stabilization structures.

As of 1965, six flood plain information reports were completed and 10 other reports were being prepared or are pending. However, full-scale non-structural management programs have as yet not been implemented as a flood damage prevention device. The structural flood control measures provide varying degrees of protection to about 3 million acres and represent an average annual damage prevention capability of approximately $150 million. However, approximately 14.3 million acres remain subject to floods, with a residual average annual damage potential of about $95.5 million, at 1965 price levels and conditions of economic development.



Channelization Provides One Means Of Flood Protection In Urban Areas

Municipal, Rural Domestic, and Industrial Water Supply

In contrast to the period of basin settlement when domestic water supply was obtained from cisterns, rainbarrels, and hand-pumped wells, over 91 percent of the basin population now has running water supplied either from central distribution systems or from individual household pressurized systems. The hazards to health which resulted from private wells being contaminated by nearby cesspools for human waste disposal stimulated development of central water systems beginning in the 1880's. The higher costs initially restricted these central systems to the larger cities. However, by 1965, over 73 percent of the basin population had public water service and 18 percent had running water from individual household systems. A total of 1,773 communities with an aggregate population of 6,280,000 now have public water service. However, about 800 incorporated communities with an aggregate population of 97,000 and 2,253,000 people living on farms, in other rural areas, and in unincorporated communities are dependent on individual water supplies. Nearly two-thirds of the rural population, or about 1.5 million people, is served by individual pressure systems. However, about 9 percent of the basin population, or one-third of the rural population (727,000), does not have running water. Recent adoption of "constant-flow" systems of water delivery, with lower pressure and storage by the user during low-usage periods, has greatly reduced system delivery costs and has brought improved water facilities within practical cost limits for many small communities and individual rural households which were previously unable to afford these services. Currently, no community with a population of 1,000 or more is without public water service.

Of the 1,773 communities with public water service, the majority (1,514) obtain their water supplies from

ground-water sources alone, whereas 209 communities utilize surface-water sources exclusively, and 50 communities utilize combined surface- and ground-water sources. In terms of the population served from public systems, almost 54 percent is served exclusively from surface-water sources and about 35 percent, exclusively from ground-water sources. Improvement in the quality of water supply from 435 public water systems is desirable, while six systems have inadequate quantity for current requirements and 134 systems require additional treatment of their water supplies. Virtually all of the communities where improved quality would be desirable obtain their water from ground-water sources.

Some industries in the basin obtain their water supply from municipal systems, but only limited data are available on separate industrial water supply systems. In 1965, 549 industries reported separate water supply systems; with 127 of these being used exclusively for cooling water and 422 for process water. Sixty percent of the process water systems and 43 percent of the cooling water systems utilize ground water exclusively; the remainder utilize surface water or combinations of surface and ground water.

Currently, the gross annual use of water for municipal, rural domestic, and industrial purposes in the Missouri River Basin is 2,787,000 acre-feet. About 12.8 percent of the gross demand, equivalent to 356,000 acre-feet annually, is consumptive use. About 21 percent of the gross demand is obtained from ground water and 79 percent from surface water, some part of which is made up of return flows from upstream uses. Summaries of the municipal, rural domestic, and industrial water supply systems are given in tables 13 and 14.

Table 13 – NUMBER OF PLACES AND POPULATION SERVED BY CENTRAL WATER SYSTEMS MISSOURI BASIN

Population Component	Total		With Public Water Service		W/O Public Water Service but With Running Water		W/O Running Water
	Places	Population	Places	Population Served	Places	Population	Population
	(No.)	(000)	(No.)	(000)	(No.)	(000)	(000)
Urban							
100,001 & over	7	2500	7	2515	0	0	
50,001-100,000	8	680	8	690	0	0	
25,001-50,000	14	560	14	572	0	0	
10,001-25,000	39	630	39	640	0	0	
5,501-10,000	52	400	52	411	0	0	
2,501-5,500	111	410	111	422	0	0	
Subtotal	231	5180	231	5250	0	0	
Rural Non-Farm							
1,001-2,500	319	531	319	531	0	0	
Under 1,000	2055	596	1223	499	832	97	
Households	[1]	913		(55)[2]	[1]	572	286
Subtotal	(2374)	2040	---	1085	832	669	286
Rural Farm	---	1340		(15)[2]	---	884	441
Total	2605	8560	1773	6280	832	1553	727

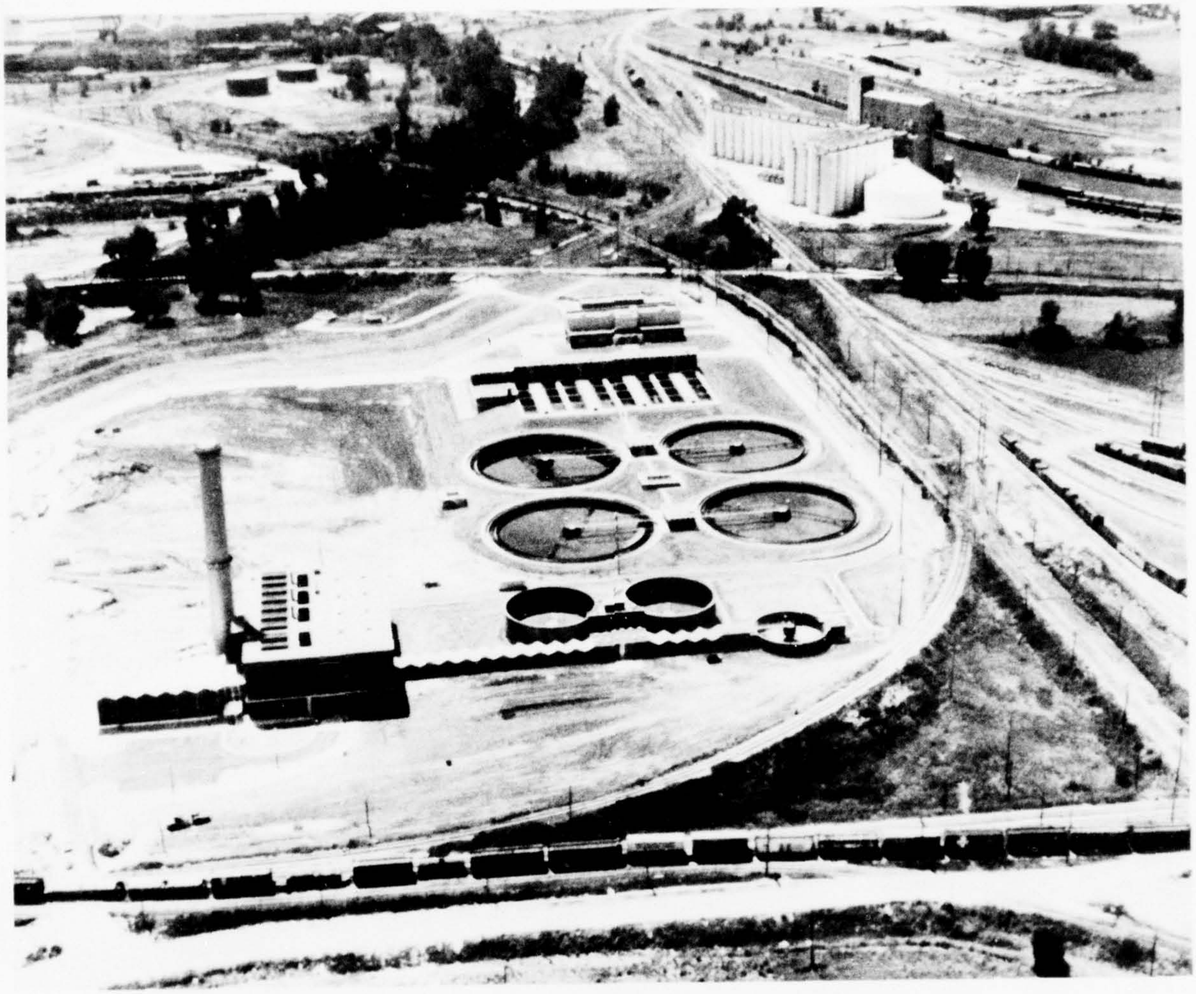
[1]Number of places not determined. Households range from single dwelling to those in an unincorporated village.
[2]Included in population served by urban central systems.

Table 14 – EXISTING INDUSTRIAL WATER SUPPLY SYSTEMS, MISSOURI BASIN

Source of Supply	Number of Reported Industries Using		Total
	Process Water	Cooling Water	
Surface	105	49	154
Ground	254	55	309
Combined Surface and Ground	63	23	86
Total	422	127	549

Sewage Treatment

As of the 1960 Federal census, there were 4,885 municipalities in the Missouri Basin, of which 1,773 communities containing 80 percent of the basin's population were served by public water systems. However, there were only 1,308 public sewerage systems, of which 1,207 provided treatment of wastes before discharging their effluent. The systems providing waste treatment included 1,009 with secondary treatment and 198 with primary treatment only. The reduction in pollution load provided by these plants was slightly over 9 million P.E. out of a pollution load of 16.8 million P.E. Also, in 1960, the number of industrial plants reported was 651, of which 49 were served by municipal sewerage systems,



Modern Waste Treatment Facilities Have Been Constructed In Many Places

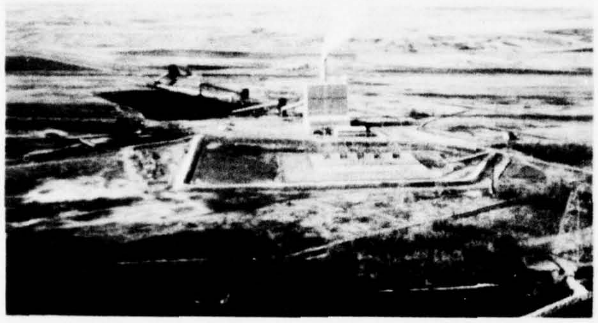
282 had separate waste treatment facilities which were adequate, 111 had inadequate treatment facilities, and 195 had no waste treatment facilities.

The 1960 inventory, up-dated to 1965, indicates there were 1,349 public sewerage systems in place with a reduction in waste loading of about 40 percent. Although a significant amount of data are available relative to municipal and industrial sewage treatment facilities, similar data on pollution loadings from the agricultural sector are limited. Pollution from agricultural lands is also a problem. This is attributed to runoff carrying decayed organic material, agricultural chemicals, barnyard drainage, and feedlot wastes into streams. Most States of the basin have recently adopted legislation designed to cope with part of this pollution problem stemming from man's activities. Degradation of water quality from natural organic material continues to be a problem.

Electric Power Generation

The electric power industry, one of the fastest growing industries in the basin, supplies power from a variety of generating plants. In 1965, the Missouri Basin contained 557 electric systems with an aggregate installed capacity of 10,155 megawatts and 1965 generation of 39 billion kilowatt-hours. In addition, non-utility generating capacity was 156 megawatts and 1965 generation was 660 million kilowatt-hours. The 557 electric systems include 359 municipal or other publicly owned systems, 164 cooperative systems, 33 investor-owned systems, and one Federal hydroelectric system. The investor-owned systems have about 50 percent of the basin's generating capacity and supply about 60 percent of the energy requirements. The remaining installed capacity is about evenly divided between the Federal hydroelectric system and the

publicly owned systems. However, the Federal system generates about 70 percent more energy than the other publicly owned systems and supplies most of the energy requirements of the electric cooperatives in the basin.



Thermal-Electric Power Plant Using Lignite Coal

The estimated energy requirement of the basin in 1965 was 37 billion kilowatt-hours. The available supply in 1965 permitted export of 2 billion kilowatt-hours from the basin. However, over relatively short time periods the export-import balances are expected to equalize.

Electric generation by steam plants using coal and natural gas provides the majority of the electric energy in the basin. In 1965, though some plants were then planned and now are under construction, there were no nuclear plants producing energy in the basin. After agriculture, the electric generating industry is the largest single water user in the basin. In 1965, the aggregate requirement for condenser cooling water was over 3.3 million acre-feet annually, requiring streamflow diversions of over 1.7 million acre-feet annually but only a consumptive use of 36,800 acre-feet annually. Table 15 summarizes the type of ownership and installed capacity of the existing power systems in the basin, excluding industrial generation.

Table 15 – COMPOSITION OF POWER SUPPLY MISSOURI BASIN, 1965

Item	Ownership				
	Investor	Cooperative	Public	Federal	Total
Type of System					
Generating (No.)	27	13	175	1	216
Distribution Only (No.)	6	151	184	0	341
Total	33	164	359	1	557
Installed Capacity					
Thermal (Mw)	4,695	154	2,398	0	7,247
Hydro (Mw)	474	0	140	2,294	2,908
Total	5,169	154	2,538	2,294[1]	10,155

[1] In 1966, an additional 426 MW of hydro capacity was installed. Thus, in 1966, the Federal capacity was 2,720 MW, the total hydro capacity was 3,334 MW, and the total basin capacity was 10,581 MW.

Recreation and Fish Wildlife

Some of the best known outdoor recreation areas of the United States within the basin are Yellowstone, Glacier, and Rocky Mountain National Parks, the Black Hills Region, and the Lake of the Ozarks area. Moreover, the six major reservoirs on the main stem of the Missouri River provide more than one million surface acres of water which is attracting increasing recreation use. Almost 19 million acres of national forests and grasslands provide land-oriented recreation opportunities in the western portions of the basin. In the more populous eastern portions of the basin, the opportunities for outdoor recreation are more limited in scope and variety and consist largely of State and local parks and privately owned facilities. These areas provide slightly more than three-fourths of the developed recreation acreage of the basin.

The inventory of recreation resources in the Missouri River Basin was divided into three classifications, consisting of scenic, historic, and natural environment areas (Type I); land-oriented recreation resources (Type II); and water-oriented recreation resources (Type III). Excluding the privately owned recreation areas, which are estimated to aggregate well over 800,000 acres of land and water, there are over 50 million acres of public lands and water areas in the basin with varying degrees of recreation potential and use. About 5 percent of this total area is water surface and slightly over one-tenth of one percent is marsh land. Slightly more than 174,000 acres, or about three-tenths of one percent of the total recreation resource area, have been developed for recreation in the sense that recreation facilities are available. The number of visitors to these facilities in 1965 was over 110 million.

Outdoor Recreation Is Popular At the Basin's Reservoirs and Lakes

About 94 percent of the area of the Missouri River Basin provides varying degrees of fish and wildlife habitat. However, only about 3 percent of this area is utilized primarily for fish and wildlife management and enhancement either as single-purpose fish and wildlife areas (0.3 percent) or as multiple-purpose areas with major fish and wildlife management aspects (2.7 percent). The areas where fish and wildlife subsist as a joint use with the primary land use function include almost all of the private agricultural lands and a substantial portion of the public lands.

Wildlife populations in the basin are as varied as the wide range of habitat which supports them. About 60 species of big game, small game, and waterfowl are sought by hunters. Deer are the most abundant big game in the basin, followed by antelope, whose range is limited to the more-open prairie regions. Pheasant is the most important upland game species, followed in importance by the bobwhite quail. Waterfowl habitat is extremely varied and very unevenly distributed in the basin. The Dakotas, in particular, provide migration and breeding habitat for great numbers of waterfowl. The 1960 and 1965 average count of wintering and breeding waterfowl in the basin was 2,192,000 and 2,394,000 birds, respectively.

Currently, the average annual harvest of game is estimated to be almost 16 million animals from 25 major species of game hunted in the basin. Big game accounts for about 2 percent of the numbers harvested; upland game birds about 60 percent; other small game about 32 percent; and waterfowl about 6 percent. The fishing waters of the basin include 43,500 miles of streams and 1,422,000 surface acres of impounded waters and natural lakes. The sport fishing capacity of these waters is estimated to be 43.1 million fisherman days annually compared to an estimated current use of 17.4 million fisherman days annually. The capacity of these waters

A Variety of Fish Abounds At the Main Stem Reservoirs

for sustained commercial fishing is estimated to be about 99.2 million pounds annually compared to actual production for marketing in 1965 of about 5 million pounds. Realization of this potential would involve large scale use of low value industrial fish - something not anticipated until at least the year 2000. Table 16 summarizes the major types and quantity of the basin resources oriented toward recreation, fish and wildlife, and related environmental quality.

Land Conservation and Drainage

Currently, 103.8 million acres of the privately-owned lands in the basin are used for crop production, 152.6 million acres are used for pasture and range, 13.7 million acres are in forest and woodlands, 3.6 million acres are in other agricultural uses, and 8 million acres are in non-agricultural uses. This amounts to 37, 54, 5, 1, and 3 percent, respectively. About 6.9 million acres of the cropland and 519 thousand acres of pasture and range are irrigated annually. An additional 1.1 million acres of land receive intermitten applications of irrigation water. About 38.6 million acres of Federal land are used for agricultural purposes, 27.6 million are grazed, and 14.4 million produce forest products. An additional 4.4 million acres of Federal land are used for non-agricultural purposes.

Table 16 – RECREATION AND FISH AND WILDLIFE RESOURCES – MAJOR CLASSIFICATIONS
MISSOURI BASIN

Type of Area	Number of Areas	Water & Land Use (1,000 Acres)		
		Water	Land	Marsh
General Recreation				
Type I, Historic, Scenic and Natural Environment	139	125	3,042	12
Type II, Land Oriented	3,091	101	41,625	9
Type III, Water Oriented	1,964	2,298	2,964	74
	Number			1,000 Acres
Fish and Wildlife				
Primary, Land and Water				9,912
Multi-Purpose				(8,764)
Single-Purpose				(1,148)
Fish Hatcheries	40			5
Fishing & Access Areas	373			80
Wildlife Refuges	65			404
Waterfowl Production	250			48
Wildlife Areas	656			439
Other				172

Susceptability to wind and water erosion damage is a serious factor affecting lands in the basin. Through their own efforts and with technical assistance and cost-sharing available to them, the owners and operators have installed adequate conservation treatment and management on 109.8 million acres, or 40 percent of the private agricultural lands in the basin. An additional 38 percent, or 102.8 million acres of management-type practices, and 22 percent, or 61 million acres of mechanical or vegetative-type practices, are needed to provide adequate levels of conservation treatment and management.

About 84 percent, or 6.7 million acres of the eight million acres that are privately owned non-agricultural lands, are used within their capability and adequately treated for erosion control. About half of the remainder need management-type conservation practices and the balance need vegetative or mechanical practices in addition to management practices.

On federally owned lands, 68 percent, or 29.3 million acres are currently adequately treated and managed. The remaining 13.7 million acres in the subbasin need improved conservation treatment and management for sustained use without deterioration.

The Conservation Program On the Great Plains Has Been Underway Since the 1930's

The evaluation of the production capability of the basin requires a consideration of feasible land use changes. Of the 103.8 million acres of land presently used for crop production, about 4.6 million acres should be converted to a less intense use such as grassland in order to reduce the erosion hazard. Conversely, of the 152.6 million acres of range and pasture under private ownership, about 20.2 million acres are classed as arable and exist in tracts large enough for conversion to cropland if the need should develop. Forest and woodland and other agricultural lands were not considered in this analysis, although some conversion of forest lands and reclamation of abandoned farmsteads will undoubtedly take place.

There are approximately 15.3 million acres of agricultural land in the basin subject to excess water problems. This total is exclusive of the 705.7 thousand acres of land with an excess water problem caused by irrigation water that is included in irrigation systems improvements. Currently, 4.6 million acres of cropland have been provided with adequate drainage. About 37 percent of this area is currently cultivated and current use would be improved by allowing timely operations and cleaner tillage of croplands. Improved farming operations that reduce weedy growth on farm croplands may depreciate their value for upland game. An additional 2.6 million acres of pasture and range and 605 thousand acres of forest and woodland are subject to problems of excess water and are suitable for conversion to cultivated uses. About 2 million acres require project-type measures to remove the excess water from agricultural lands. The balance can be treated by individual land owners and operators.

About 5.3 million acres, or 35 percent of the land with excess water problems, are considered infeasible to

drain. Of this total 644 thousand acres are currently used for cropland and should be converted to non-crop use. This entire 5.3 million acres should be used for grazing and woodlands including management to utilize its natural value as wildlife habitat.

None of the agriculture land having potential for improvement by excess moisture disposal is covered with surface water frequently enough to have any appreciable value to waterfowl. However, group solutions to the agricultural land problems may involve intermittently wet areas used occasionally by waterfowl.

Navigation

The authorized improvement of the Missouri River for navigation between Sioux City, Ia. and the mouth has not quite been completed to its design draft of 9 feet. However, in 1966, barge traffic on the waterway carried 2.6 million tons of freight, an equivalent of 1.2 billion ton-miles. Sixty percent of the tonnage currently being moved on the waterway is farm products (primarily grain), about 11 percent is food and kindred products, 10 percent is chemicals, and the remaining tonnage includes petroleum products, metal products, stone, clay, paper, and textiles.

Barge Movements on the Missouri River Provide One Mode of Transportation

Sewage Treatment Plant at Billings

CHAPTER 5

WATER AND RELATED LAND REQUIREMENTS

Projections of requirements for use of land and water resources in the Missouri River Basin involved the appraisal of existing conditions and of the capability of the resources to fulfill anticipated economic, social, and physical demands that might be placed upon them. A functional approach was used to determine resources needed to completely fulfill human requirements and desires for municipal, rural domestic, and industrial water supply; water quality control; irrigation; livestock water supply; drainage; rehabilitation of irrigation facilities; flood and erosion damage prevention; navigation; electric power; agricultural land management and conservation; transportation, urban, and built-up areas; mineral uses; productive forest uses; fish, wildlife, and recreation; and general enhancement of the quality of the environment.

Use of a functional approach, results in some instances, in forecasts in which demands exceed the available water and related land resources if single-purpose development or management programs are to be formulated. On the other hand, several uses are compatible, or at least non-conflicting to some degree, for joint use of the resource base. Maximum use of the resources as a means for satisfying, to a reasonable extent, all functional requirements, requires the concepts of joint use, multiple use, and in some instances their reuse. It was necessary, therefore, to consider the reliability of demand projections, the functional competitive relationships, and the magnitude of the resource base as steps in formulating a plan designed to assure and to safeguard the interests of the public.

The projections of functional demands and desires are discussed individually in the following paragraphs with a more detailed presentation included in the appendix, "Present and Future Needs". Inter-relationships and possible conflicts between the several functions are here identified to provide guidelines in selecting between alternative courses of action for implementing a plan in the Missouri Basin for the conservation, development, management, and use of water and related land resources.

GENERAL PROCEDURES

Projections of functional demands and desires for various types of goods and services for the target years 1980, 2000, and 2020 were developed by technical people representing the participating Federal agencies and State agencies and having broad knowledge and experience in their respective fields. The methodology used in projecting future demands varies according to the functional use of the resource and depending upon the data and knowledge available for consideration, or the adaptability of knowledge to projection techniques. Under these conditions, there is considerable variability between the several projections of individual functional demands.

From a planning viewpoint, the adequacy of each projection was weighed against that of the other projections and judgment was applied in determining planning criteria aimed at satisfying, quantitatively, identified functional demands.

AGRICULTURE AND FORESTRY

Projected requirements for food and fiber in the Missouri River Basin are a component part of projected national requirements. The national projections were determined through consideration of major forces which influence demand. Major factors related to requirements are population, per capita income, consumer's taste and preference, industrial uses, livestock feeding efficiencies, imports, and exports. Since projections have diminishing accuracy over time, most of these parameters were projected to 1980 only. The 2000 and 2020 projections are primarily a function of changes in population, with per capita consumption held constant.

The Missouri Basin's share of national production requirements for food grains, feed grains, and livestock was determined by a national-inter-regional analysis of historical shares and trends. Roughage requirements were determined regionally from livestock requirements and projected livestock feeding efficiencies and ration requirements.

The resulting commodity requirements are presented in detail in the appendix, "Present and Future Needs".

These requirements were aggregated as production indices for total cropland and forage (pasture and range) production. Table 17 summarizes projected cropland and forage production expressed by index numbers above the current normal base.

Table 17 – AGRICULTURAL PRODUCTION REQUIREMENTS IN TERMS OF CROP AND FORAGE FOR THE MISSOURI BASIN

Year	Production Requirements Index
Current Normal	100
1980	134
2000	164
2020	207

A generalized analytical model was used to project production patterns and to compare the capacity of the basin's agricultural resources to meet the projected regional requirements. The mathematical process used, linear programming, is an automated form of enterprise budgeting. Basic assumptions and significant features of the model are discussed in the appendix, "Present and Future Needs".

In order to fully assess the capability of the basin in relation to projected national food and fiber requirements, it was necessary to proceed with plan formulation to determine all the factors affecting agricultural production. The estimates of projected capability of agricultural land in future time periods required recognition of emerging research and technology, improved management, and other related programs such as on-farm conservation treatment, irrigation development, livestock water improvement, and such other on-farm measures which are embodied in historical trends. In addition, enhancement or stabilization of agricultural production through further water resource development, such as flood control and drainage required quantification for eventual comparison with projected requirements. These evaluations are presented and discussed in chapter 8.

Further complicating the agricultural production requirements for the basin, is the inability at this time to demonstrate its capacity and efficiency with respect to other water resource regions. The ability of these other regions to meet their shares of national requirements beyond 1980 is unknown. Therefore, future analyses of national-interregional capacities and relative efficiencies may require substantive changes in allocated regional shares of projected national production requirements.

Aside from their share of the projected Nation's food and fiber needs, and their ability to fulfill those needs, the residents of the basin, and the Nation for that matter, are interested in many other objectives. These include such items as the preservation of natural resources, alleviation of economic losses, maintenance and improvement of the physical and social environment, stabilization of annual production and income, maintenance of the rural population, raising of low incomes, perpetuation of the farm family as an economic farm unit, and general stability and growth of the basin's economy founded heavily on agriculture. These objectives embody the desire to improve the course of economic growth with respect to the Nation and to attain all practicable stability not only in the basic agriculture but in the many industrial and service activities heavily dependent thereon. In long-range planning there is need to consider these objectives as well as the basin's share of projected national food and fiber requirements and how the national and regional objectives in agriculture may finally relate to each other.

Irrigation

Irrigated agriculture has progressed over most of the basin recognizing the need to stabilize and enhance agricultural production naturally subject to inadequacies in moisture supplies. Undertaken early in the western and more arid portions of the basin, development has progressed eastward, with all but the Lower Missouri Subbasin showing significant acreages under irrigation service in 1965. Recent development has progressed at the rate of about 200,000 acres added per year. Possibly 30 percent of the existing development is from groundwater supplies where irrigation is the only purpose served. For the remaining 70 percent served by surface waters, the often associated storage features for many developments also serve one or more collateral purposes of flood control, hydroelectric power production, recreation, fish and wildlife, and municipal and industrial water supply. Aside from the lands irrigated, their stabilized and increased production helps stabilize a large periphery of non-irrigated agricultural operations, particularly as regards livestock.

Irrigated acreages were projected, based on those developments envisioned and desired by local interests and which appear logical and feasible with respect to multiple-purpose resource development. On this basis, table 18 summarizes the current and projected irrigation acreages for each of the eight subbasins. These projections reflect a major regional objective to attain certain levels of an agricultural economy and include judgments as to availability of water, relative quality and efficiencies of water supplies, suitability of lands, and the ability of the farm operators to assume the necessary financial costs. As presented in the appendix, "Land Resources Availability", about 64 million acres of land are potentially suitable for irrigation. Of this amount, less than 12 percent, or 7.4 million acres are currently being irrigated with a full water supply. Projections to 2020, as shown in table 18, indicate that irrigation

Table 18 – CURRENT AND PROJECTED IRRIGATION ACREAGE
MISSOURI BASIN

Subbasin	Current Full Irrigation	Current Intermittent Irrigation	Additional New Irrigation 1980	2000	2020
	(Thousand Acres)		(Thousand Acres-Incremental)		
Upper Missouri	1,102	418	192	215	143
Yellowstone	1,188	235	190	263	184
Western Dakota	209	198	156	210	396
Eastern Dakota	119	113	229	522	976
Platte-Niobrara	2,986	150	769	728	864
Middle Missouri	103	0	239	606	786
Kansas	1,703	0	730	564	923
Lower Missouri	5	0	230	359	381
Missouri Basin	7,415	1,114	2,735	3,467	4,653

development could be in excess of 18 million acres, or about 29 percent of the potentially irrigable land. During detailed plan formulation, these projections must be tested to insure that the initial judgments are reasonable and any competitive situations are resolved.

Rehabilitation of Group Irrigation Systems

Of the land currently irrigated in the basin, about 5.8 million acres are serviced by group irrigation systems. Potentials for improving the efficiency, or output, from the systems depend on the solution to one or more of three general problems: (1) water shortages during the crop growing season; (2) drainage problems; and (3) high operation and maintenance costs. Solutions to the problems in each category normally would consist of one or more improvements including: (1) added water storage, improvement of delivery systems, canal and lateral lining, and facility consolidations; (2) installation of group drainage ditches, land preparation, smoothing, and leveling; and (3) reorganization and consolidation of present canal systems, including lining and protection against erosion.

Analyses were made to determine the maximum amount of rehabilitation that could be accomplished to increase efficiency, considering physical quantities and cost factors. Since the objective is to increase efficiency, during the planning process the maximized physical quantities were scaled to meet the concept of efficiency gains. With the planning constraint noted, table 19 summarizes the maximum potential for rehabilitating and reorganizing existing group irrigation facilities.

Table 19 – POTENTIAL REHABILITATION AND REORGANIZATION MEASURES FOR GROUP IRRIGATION SYSTEMS, MISSOURI BASIN

Subbasin	Ditch Consolidation	Ditch Lining	Storage Requirements	Drainage Ditches
	(Miles)	(Miles)	(Thousand AF)	(Miles)
Upper Missouri	2,183	1,057	240	396
Yellowstone	736	1,046	351	957
Western Dakota	21	34	27	10
Eastern Dakota				2
Platte-Niobrara	426	2,466	562	3,240
Kansas	2	789		25
Missouri Basin	3,368	5,392	1,180	4,630

Forestry

The annual harvest of timber resources is about one-half of the annual growth in merchantable-size timber. The national demand for forest products is expected to increase about 33 percent by 1980, 100 percent by 2000, and 200 percent by 2020 from a 1962 base. Net annual growth in merchantable-size timber is expected to increase at nearly the same rate as timber use. It is anticipated that growth in merchantable-size timber will exceed cut by about 200 million cubic feet annually in 2020. There appears to be no need for changes in land use for timber products through the study projection period. However, intensive management of forest cover has a significant role in the maintenance of the water resources. In some locations changes in land use may be desirable to provide forest and woodland areas for maintaining and improving the general environment of the area.

WATER SUPPLY

Water supply studies, exclusive of the irrigation studies already described, embraced the following uses:

municipal, industrial and rural domestic; thermal electric power; livestock; and mineral. Generally, the future gross water requirements within the subbasins were based on projections of population and other economic parameters applicable to the uses cited. Table 20 illustrates the overall magnitude of the gross water required, but these values do not reflect adequacy of supply, location, consumptive use, and water returned to the streams for further use and re-use. Establishment of net demands, therefore, required not only a stream analysis, but also plan formulation criteria which took into account the factors mentioned.

Table 20 — WATER WITHDRAWALS REQUIRED FOR SELECTED USES BY 2020

Subbasin	M&I, Mineral, and Rural Domestic	Thermal Cooling	Livestock	Total
	(Thousand Acre-feet Above 1965 Base)			
Upper Missouri	77	455	44	576
Yellowstone	1,085	778	41	1,904
Western Dakota	74	349	65	488
Eastern Dakota	136	684	92	912
Platte-Niobrara	954	-252	187	889
Middle Missouri	373	757	136	1,266
Kansas	185	33	100	318
Lower Missouri	819	350	129	1,298
Missouri Basin	3,703	3,154	794	7,651

Municipal, Industrial, and Rural Domestic Water Supply

The economic projections presented for the individual subbasins were disaggregated to a considerable degree to assist in determining the location and magnitude of water supply demands. The water supply studies embraced future water demands, based on extrapolation of current water use practices and tempered by technical judgments to allow for anticipated trends. Data regarding present water supplies are those reported as of 1965 from both published and unpublished sources. In some instances, data on improvements and expansion of existing supplies accomplished subsequent to 1965 were not available and, consequently, were not included in the inventory. However, these improvements were taken into account by the planning groups in determining future needs.

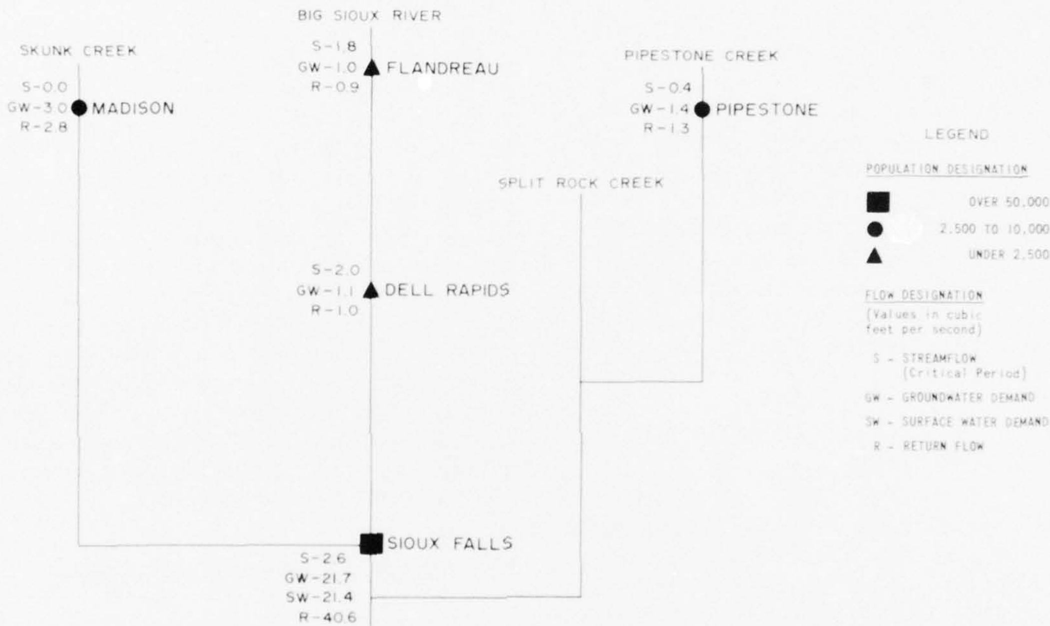
A detailed description of the studies made to determine future water supply requirements is contained in the appendix, "Present and Future Needs." Gross water demands are based on per capita use rates, or on industry use rates as established from the basic water supply studies. The use rates were applied to projected population and economic activity levels to establish the gross water demands. The gross demands reflect a withdrawal requirement at a point of use. These demand values illustrate the overall magnitude of water required, but they do not reflect sources of supply, location, consumptive use, and water returned to the stream for further use. Therefore, in order to establish needs, extensive water budgets were prepared for each stream system which delineate the demand points within each of the subbasins. In essence, the net demand or need analysis became a planning function since acceptable shortage criteria had to be established and a system analysis made to determine deficiency points and the alternative ways in which water could be made available to meet the needs. It follows that this analysis also indicated those points where supplies would be adequate through the projection period.

Figure 16 illustrates the typical system analysis made to determine the net demands, or needs, at various locational points in a selected stream system. For example, the Sioux Falls demand point for target year 2020 indicates a gross withdrawal requirement of 21.4 cfs from surface water and 21.7 cfs from ground water, and the critical low-flow value of 2.6 cfs, or an indicated deficiency of 18.8 cfs from the surface water demand alone. Assuming that the deficiencies would be met through some type of developmental program such as a dam on the Big Sioux River and additional wells, the return flow to the stream would be 40.6 cfs which means the consumptive use would be 2.5 cfs. The planning criteria used and the general relationships with other functional demands for water are presented and discussed in the next chapter. Factors of supply, consumption, and return flows for further use, as illustrated, establish the demand pattern, but the very nature of these demands and factors associated therewith precludes a concise or convenient summation by subbasin or basin totals.

Since gross demands reflect per capita use rates, they are sensitive to the projections of future populations. Short-term projections to the 1980 level are well within allowable error limits for this type of study. They are, therefore, adequate for guiding actions to develop supplies to meet demands before any water crisis would occur. A similar situation with respect to the long-term projected trends (to 2020) would also prevail. If downward or upward shifts in long-term population growth or in per capita use rates should become evident

in the future, a number of options would have to be explored. These would include delaying development, or developing additional supplies, re-use or re-cycling of water, conversion from other uses, and possibly rationing and pricing policies to restrict usage for certain purposes. The freedom in possible courses of action outlined illustrates the flexibility of a framework plan, recognizing of course the legal and institutional arrangements as applicable. The projected future net requirements for municipal, industrial, and rural domestic water supply imply price considerations which, along with the preferential status for their use of water, puts it into a highly dominant position with any other possible competitive demands.

FIGURE 16
TYPICAL FLOW DIAGRAM OF
MUNICIPAL AND INDUSTRIAL WATER SUPPLY
IN THE YEAR 2020



Industrial Water Supply

Separate industrial water requirements, exclusive of mining, were estimated for those heavy water-using industries not connected to municipal sources of supply. Actual industrial use data were reported where available. Sources of most recent data included the Bureau of Census, Bureau of Mines, Federal Water Pollution Control Administration, and State, city, and county records. Where possible, use records were obtained and unit use determined. Future gross demands were developed for each diversion point as previously described. Return flows were estimated for each type of industry and analyses similar to those described for municipal water supplies were made to determine net demands or needs.

The projections of future water requirements for industries not connected to municipal systems could be greatly understated. Not only are data on water use by existing industries incomplete and fragmentary, but studies of possible future industrial patterns have not been made. The framework plan itself could suggest certain developments that would require significantly more water than indicated by the initial projections. Accordingly, the plan formulation process for this category of use (as well as others) was not constrained by the economic projections or indicated water needs based on such projections. Also, continuing adjustments should be made to the framework plan in the future as the population-industrial mix is defined more clearly.

Livestock Water Supply

The future needs for livestock water are based on subbasin projections of livestock production. Information on livestock water requirements is reported by surface- or ground-water sources of supply. Except in limited isolated areas, water supplies are adequate to meet the requirements of livestock. However, the development of supplemental sources to augment natural water supplies would permit better utilization of the range grazing resource.

Throughout the basin, uses of water for domestic purposes are assigned the highest priority under State law. This is not the case in some States with respect to a preferential status for livestock water. Quantities withdrawn and consumed for both of these purposes are relatively small. However, the storage of surface waters for livestock use results in depletions due to evaporation losses in the arid portions of the basin and could result in competitive demands for scarce supplies.

The economic and social necessity for livestock water use dictated action to provide for such use in plan formulation. The great variance in, and localized nature of, the problem required general treatment after consideration of the available supply of ground and surface water, water quality, climatic conditions, and distribution of electric power supplies.

The projected future water requirements for livestock use are dependent on base projections. These projections indicate a significant increase in livestock production. From a regional standpoint, economic and social objectives are aimed at dampening, to some extent, the loss of farm population and intensifying agricultural production. The initial projections are, therefore, adequate for planning purposes, but will have to be reviewed, and adjusted as necessary, taking into account the effects of a long-range plan.

Electric Power Water Supply

Studies to project the future electric power needs of the basin were conducted as an integral part of the Federal Power Commission's National Power Survey. With minor exceptions, the power study area coincided with the external boundaries of the Missouri River Basin. However, the subbasin boundaries and population disaggregations used in the comprehensive framework study did not lend themselves conveniently to power analysis. Therefore, projected electric power requirements were based on the FPC Power Supply Areas (PSA's). Each PSA represents essentially the service areas of related groups of major electric utilities. The projected PSA power requirements and consumptive water use were then disaggregated to the subbasins.

Power studies covered hydroelectric and thermal sources as well as private and public sources and distribution systems. While the location of fuel reserves was reported, the study is not in sufficient detail to permit a firm location of future generating plants or distribution lines.

Water requirements for hydropower production are non-consumptive and are limited by the existing pattern of operation and the few remaining structural sites suitable for development. Cooling water requirements for thermal-electric plants were determined for each subbasin in terms of condenser cooling water requirements, required streamflow diversions, and cooling water losses. This degree of estimating is adequate for the purposes of this study. It does reveal that each future proposal for locating thermal-electric power plants must seriously consider the effect of withdrawal and consumptive use of water, and the temperature effect on other water uses, both locally and regionally.

Although the projections of future water requirements are documented, the demands for cooling water are not susceptible to simple evaluation. The complexity of the evaluation can be traced to the alternatives available for cooling purposes. The cheapest cooling form is a flow-through system with a very small part of the water lost through consumption, but with significant temperature rises in the return flow. As an indication of the magnitude of such future cooling water requirements, a summation of projected gross withdrawals approach 4.9 million acre-feet annually by the year 2020, which allows for the use of supplemental type cooling systems. By introducing closed systems and cooling towers, problems such as temperature increases and water quantity are minimized, but this can be achieved only through additional cost. Within the plan formulation process, therefore, it was necessary to weigh all factors in order to determine the best possible course of action. These included recognition of beneficial as well as detrimental effects, the costs involved, and the probable reaction of the consumer and his willingness to pay for maintaining certain economic and social values that may otherwise be lost.

Water Supply for Mineral Development

Additional water required for future mineral development and processing is projected for all subbasins. Gross water withdrawal requirements for metals, non-metals, fuels, and sand and gravel approach 538,000 acre-feet annually by year 2020. Of this amount, 346,000 acre-feet are for sand and gravel processing.

FISH AND WILDLIFE

The demands and desires for fish and wildlife in the Missouri Basin and its subbasins were determined by the several State fish and wildlife agencies and the Bureaus of Sport Fisheries and Wildlife and Commercial Fisheries. The study included an inventory of lands and water dedicated primarily to fishing and hunting, and areas where fish and wildlife is an ancillary use. The single-purpose category includes lands owned or controlled by State fish and game agencies and the Bureau of Sport Fisheries and Wildlife. Primary use lands are public and private lands where fish and wildlife is one of the principal multi-purpose uses. Identified also were the areas of habitat or range for select fish and game species

present in the basin. The inventory shows that while virtually all of the land and water area in the basin is of value to fish and wildlife, only 0.3 percent of the area is dedicated to this use and only 3 percent of the total basin area is considered as primary fish and wildlife lands and waters.

The discussion presented in the appendix, "Present and Future Needs," points out the general deterioration of fishing waters from the activities of man. The deterioration results in varying degrees from overgrazing; dewatering of streams for irrigation and other purposes; siltation from natural phenomena, construction practices and agricultural lands; strip mining, logging, and municipal, industrial, and agricultural waste discharges. The inventory establishes that a surplus of fishing opportunities currently exists within the basin, although the maldistribution of certain fishing waters in relationship to population centers does not contribute to full utilization of these opportunities. A considerable potential for commercial fishing is present, but is relatively unused due to the low price for products as compared to current costs of harvesting and processing. Restrictive laws also reduce the current level of commercial fishing, often in the interest of preserving sport fisheries.

Waterfowl habitat is extremely varied and unevenly distributed throughout the basin. Populations vary from season to season dependent upon the condition of wetland breeding grounds and other influencing factors. As with the fishery resource, there is presently a surplus of total hunting opportunity within the basin although the distribution of these opportunities, hunting success, and quality of experience reduce full utilization of the resource. Waterfowl hunter demand already is greater than the capacity of the birds and habitat to support it at the "good quality level" and big game hunter use is near that capacity.

Projections of demands for fish and wildlife are based on human use of this resource as a recreational outlet. While present capacity exceeds current use of the resource base for both hunting and fishing, projections indicate a substantial shortage of hunting and fishing opportunities by 1980 and thereafter without further development and management.

The methodology for projecting fish and wildlife demands incorporates a factor of "latent demand" inherent in a population not reflected in the use of existing resources that could be expected if quality hunting and fishing opportunities were located more conveniently to an individual's place of residence, or with shifts of socio-economic conditions. This methodology assumes that a "use rate" is equivalent to *current experience in a given area plus an increase in the* use based on experience in other areas of quality opportunity (the latent demand). It is recognized that consumer preference for these types of activities is difficult to project over the long term. Since there are innumerable alternative recreational pursuits that are or can be competitive in the future, the projected demands may have a substantial range of values. However, the projected demand values adopted for this study are considered adequate targets for framework planning purposes. Future experience of consumer preference will more clearly define effective demands and the development or management requirements to meet them. Tempered by the interpretation of these factors, table 21 summarizes net demands for future fishing and hunting. Negative values in the table indicate that the estimated capacity can support uses beyond projected demands.

Table 21 — PROJECTED NET HUNTING AND FISHING DEMANDS, MISSOURI BASIN

Subbasin	Fisherman-Days (1,000)			Hunter-Days (1,000)		
	1980	2000	2020	1980	2000	2020
	(Cumulative Above Current)					
Upper Missouri	-3,330	-2,815	-1,893	-546	-160	96
Yellowstone	-2,662	-1,978	-705	-259	27	437
Western Dakota	-2,451	-1,967	-1,239	-849	-584	-285
Eastern Dakota	-3,800	-3,169	-2,382	-785	199	1,160
Platte-Niobrara	241	5,344	13,182	4,265	7,380	10,886
Middle Missouri	1,157	2,118	3,511	684	1,416	2,441
Kansas	-147	920	2,288	684	1,507	2,541
Lower Missouri	5,482	9,853	15,401	2,465	5,049	8,844
Missouri Basin	-5,510	8,306	28,163	5,659	14,834	26,120

Intra-Missouri Basin demand for freshwater fish products calculated from national trends is expected to increase from 3.2 million pounds in 1960 to 15 million pounds by 2020. As was pointed out in chapter 4, the capacity of the fishing waters of the basin to sustain commercial fishing is on the order of 99 million pounds annually. The cited demand, therefore, is well below the total existing capacity. However, commercial fishery demand may go beyond intra-basin markets since production and consumption do not necessarily take place in the same basin or region. The Missouri Basin, therefore, has a substantial commercial fishery capacity to support demands outside the basin if markets for the commodity should materialize over the long-term future.

RECREATION

Recreation needs for the Missouri Basin were determined by application of Outdoor Recreation Resources Review Commission methodology to the population projections resulting from the economic study, with some deviation. The recreation study reported in the appendix, "Present and Future Needs," included an inventory of public recreation facilities, current use in terms of "recreation days," participation by activity, and delineation of use by basin residents and nonresidents. Both the demand, defined as the anticipated impact on recreation resources, and the need, defined as the additional requirements for land, water, facilities, or management necessary to meet the demand, are reported for the basin and subbasins.

The needs for outdoor recreation functions are presented for the most part in terms of acres of land or water, although some satisfaction of the demand can be realized through altered management practices or additional facilities on existing land dedicated to recreation use. As with the fish and wildlife function, many of the recreation needs can be met by multiple use of lands serving other primary purposes.

The study illustrates that the most critical present and near-future needs are associated with urban, suburban, and outlying metropolitan influence areas. Additional lands and water developed for intensive recreational use will be required to meet needs associated with the population centers. Thus, the foregoing discussion of the demand projections for the fish and wildlife function, especially pricing considerations, are generally applicable to the related general recreation function and further discussion on projected recreation demands is not repeated here.

In general, water area deficits within the basin result from a wide geographic imbalance between supply and demand. Again, the deficits, in many instances, are associated with densely populated areas. Small water impoundments, 300 acres or less, are considered desirable to meet both fish and wildlife and recreation needs of urban people.

Table 22 summarizes projected recreation needs and requirements. In many instances, water surfaces and lands can be used for both general recreation and fish and wildlife purposes and this multi-use potential was recognized during plan formulation. Moreover, extensive indicated "need" for undeveloped land reflects a requirement for a desirable quality recreation environment.

During detailed planning, many factors will have to be recognized in establishing the need for the extensive land program of "undeveloped" lands for a high quality

Table – 22 PROJECTED RECREATION NEEDS, MISSOURI BASIN

Subbasin	Recreation Days			Water			Developed Land			Undeveloped Land		
	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
	(Million)			(Cumulative Above Current – Thousand Acres)								
Upper Missouri	8	18	29	6	11	30	17	38	59	253	445	657
Yellowstone	6	15	28	3	14	30	13	32	57	129	393	723
Western Dakota	3	8	14	4	12	41	13	48	71	116	428	605
Eastern Dakota	7	16	27	19	37	66	14	32	55	220	377	584
Platte-Niobrara	26	64	121	21	221	530	40	97	182	113	418	805
Middle Missouri	13	26	43	96	220	355	14	30	50	159	250	359
Kansas	8	18	31	18	61	114	12	26	44	138	230	344
Lower Missouri	19	41	72	60	144	370	29	65	83	64	266	356
Missouri Basin	90	206	365	227	720	1,536	152	368	601	1,192	2,807	4,433

recreation environment. These factors include economic values, both tangible and intangible, and the institutional and legal arrangements required to carry out such a vast land program.

WATER QUALITY CONTROL

Water demands for quality control were determined from an inventory of projected municipal and industrial pollution sources; computation of the quantity of water in the receiving stream required to assimilate treated waste discharge; and comparison of theoretical indices of residual pollution with selected water quality criteria. Water quality criteria used in the methodology were agreed to by study participants prior to the adoption of water quality standards by the States and their acceptance by the Secretary of the Interior. Only selected water quality parameters were considered in this study. Others may be controlling for specific uses.

Table 23 contains the general range of values adopted by the ten basin States and those values used in the framework study. A comparison of the criteria values indicates that the water quality criteria used in the framework study were equal to or compatible with the more recently established State standards.

The study assumes, in estimating required streamflows to meet water quality criteria, that all wastes will receive the equivalent of secondary treatment with

Table 23 — WATER QUALITY CRITERIA, MISSOURI BASIN

Measure	Maximum or Minimum Limit	Unit	Range of State Values	Framework Study Values
Dissolved Oxygen	Minimum	mg/l		
Cold Water Fisheries			6 or 7	7
Warm Water Fisheries			5	5
Domestic			3 or 4	
Industrial			3	
Total Dissolved Solids	Maximum	mg/l		500-1,500
Domestic			500 to 1,000	
Agriculture			700 to 1,500	
Temperature Increase	Maximum	Degree F.		5
Cold-Water Fisheries			0 to 5	
Warm-Water Fisheries			0 to 10	

biochemical oxygen demand (BOD) removal of 85 percent by 1980, 90 percent by 2000, and 95 percent by 2020. The stream loading resulting from discharge of similarly treated industrial wastes was estimated by considering their domestic-waste equivalent.

Table 24 summarizes the sewage treatment facilities required to treat municipal and industrial wastes from municipal sewerage systems to achieve BOD removals of 85, 90, and 95 percent at the 1980, 2000, and 2020 target years. Additional detail with respect to municipal waste treatment needs are included in the appendix, "Present and Future Needs."

Some shortcomings inherent in the water quality studies include the lack of reliable data necessary to analyze the effect of agricultural pollution sources associated with irrigation return flows, the residual agricultural chemicals in runoff, and the effect of livestock feeding operations on streamflow or ground

Table 24 — FUTURE MUNICIPAL WASTE TREATMENT NEEDS

Subbasin	Water Treatment Needs: Gross Load	Residual Load After Treatment	Treatment Facility Needs: Enlarge Secondary Facilities	Add Secondary Facilities	New Secondary Facilities	Add Tertiary Facilities	New Tertiary Facilities
	(Thousand PE)[1]		(Number)				
1980							
Upper Missouri	600	90	66	14	20		
Yellowstone	385	58	38	18	9		
Western Dakota	540	81	75	14	21		
Eastern Dakota	1,200	180	168	33	74		
Platte-Niobrara	10,400	1,560	168	52	130		
Middle Missouri	6,000	900	118	22	160		
Kansas	1,570	236	198	30	122		
Lower Missouri	3,875	581	178	15	195		
Missouri Basin	24,570	3,686	1,009	198	731		
2000							
Upper Missouri	830	83	90		5		
Yellowstone	580	58	60		5		
Western Dakota	780	78	100		10		
Eastern Dakota	1,760	176	240		25		
Platte-Niobrara	16,600	1,660	270		50		
Middle Missouri	7,890	789	200		10		
Kansas	2,200	220	250		25		
Lower Missouri	5,875	588	290		155		
Missouri Basin	36,515	3,652	1,500		285		
2020							
Upper Missouri	1,060	53				105	65
Yellowstone	775	39				70	30
Western Dakota	1,080	54				120	80
Eastern Dakota	2,320	116				300	100
Platte-Niobrara	26,640	1,332				400	100
Middle Missouri	8,200	410				310	90
Kansas	2,920	146				375	325
Lower Missouri	8,750	438				543	857
Missouri Basin	51,745	2,588				2,223	1,647

[1]Population Equivalent of Wastes

water. Neither can the effect of temperature rise from industry cooling water and thermal power installations be fully identified or evaluated, although probable locations and effects were considered. As pointed out under the discussion on electric power water supply, each thermal powerplant operation considered in the future must be analyzed for its effect on water temperature and water quality deterioration. The study did not consider temperature reductions resulting from reservoir releases. However, design of outlet structures can compensate by maintaining temperatures at desired levels.

Projections of water quality control needs in terms of low-flow augmentation were developed concurrently with other water requirements during plan formulation since it was necessary to consider alternative programs for providing the most efficient solutions.

NAVIGATION

As presented in the appendix, "Present and Future Needs," a review of navigation improvements on the Missouri River was made, generally with respect to the adequacy of the existing navigation project between Sioux City and the mouth of the Missouri River and a general identification of future water transportation opportunities in the basin. With respect to the existing project, the study shows that flow rates of 25,000 to 31,000 cfs at Sioux City, Ia. and 31,000 to 41,000 cfs at Kansas City, Mo., would be adequate to support a 9-foot navigation channel. In the event future upstream uses should deplete the water supply as to seriously impair the services of the navigable waterway, a number of alternative courses of action are available. These include abandonment of the waterway as a transportation mode, canalization of the river, shortening the navigation season, or increasing the water supply by water imports.

Recent studies indicate that extension of the upstream limit of the navigable waterway from Sioux City to Gavins Point Dam is economically feasible and could be implemented in the future. In addition, probable need for navigation improvements on the Kansas River below Turner, Kans., and on the lower 3 miles of the Grand River in Missouri are indicated. Plan formulation studies, therefore, considered not only additional navigation improvements that may be warranted, but also the future water supply situation as well as the legal framework affecting implementation.

FLOOD AND EROSION CONTROL

Analyses of the flood and erosion problems were based on identification of areas susceptible to flooding or erosion and estimates of losses that could be expected in these areas under current conditions. Sufficient data were available to make a fairly definitive study of current levels of flood damages and gully erosion. For streambank erosion, however, a generalized assessment was made to determine the miles of channel undergoing erosion and the amount considered to be serious.

For floods and erosion, projected levels of damages were based on broad indicators of economic activity expected to prevail in the future and with protection afforded by existing projects. The projected damage levels, which for the most part reflect historic trends, are considered to give a reasonable picture of the magnitude of future flood problems in the absence of any future programs, either structural or non-structural. Such projections remove possible bias during plan formulation and permit the formulation of a program encompassing both structural and non-structural measures. The projections, therefore, reflect continued economic expansion with no dampening factors. On the other hand, they do not infer an absolute "need" or "demand" that must be met by developmental or management programs. Planning criteria presented in the next chapter outlines acceptable levels of damage reduction for consideration during plan formulation. On the basis described, tables 25, 26, and 27 summarize current and projected future damages stemming from floods, streambank erosion, and gully erosion, respectively.

The average annual values do not provide a total basis for planning purposes. In many instances, positive flood and erosion control programs result in an enhancement of the affected area, usually through a change in land use. Measurement of this effect can be made by determining the income differences brought about by the program. This leads to the need to correlate flood and erosion protection programs with such other programs as increased agricultural production through improved technology and irrigation practices, restrictive management of flood plains versus urban expansion, and other uses of flood plain areas. The advantages of such correlation are not directly obvious from projected damage levels. For example, the reduction of sedimentation in storage reservoirs permits not only longer useful reservoir lives, but also better water quality for recreation and fish and wildlife and other uses. The factors outlined are applicable to single-purpose as well as multi-purpose programs.

LAND CONSERVATION AND DRAINAGE

As stated in chapter 4, about 60 percent or 165 million acres of the 274 million acres of privately owned land in the basin requires the installation of conservation practices to provide adequate protection and to maintain or improve fertility. Of this amount, 103 million acres need the installation of management-type practices, while 62 million acres need management plus the installation of vegetative or mechanical-type practices. In

Table 25 – FLOOD DAMAGES WITH CURRENT AND PROJECTED ECONOMIC DEVELOPMENT MISSOURI BASIN

Subbasin	Average Annual Damages			
	Current	Projected		
	1965	1980	2000	2020
	($ Thousand)			
Upper Missouri	1,517	2,887	5,220	10,007
Main Stems	999	2,018	3,833	7,622
Tributaries [1]	518	869	1,387	2,385
Yellowstone	2,082	3,671	7,059	14,160
Main Stems	1,257	2,268	4,619	9,464
Tributaries	825	1,403	2,440	4,696
Western Dakota	2,347	4,100	6,205	12,302
Main Stems	915	1,696	2,912	5,351
Tributaries	1,432	2,404	3,293	6,951
Eastern Dakota	5,721	11,335	18,668	30,598
Main Stems	2,401	4,941	8,477	13,493
Tributaries	3,320	6,394	10,191	17,105
Platte-Niobrara	15,661	27,125	48,452	83,353
Main Stems	7,259	13,635	27,856	49,797
Tributaries	8,402	13,490	20,596	33,556
Middle Missouri	14,969	23,258	34,702	50,100
Main Stems	9,050	14,275	22,101	32,408
Tributaries	5,919	8,983	12,601	17,692
Kansas	19,631	30,126	44,544	67,904
Main Stems	5,009	7,887	12,652	20,967
Tributaries	14,622	22,239	31,892	46,937
Lower Missouri	33,620	50,033	76,420	123,836
Main Stems	19,763	29,437	45,784	75,802
Tributaries	13,857	20,596	30,636	48,034
SUMMARY:				
Total Main Stems	46,653	76,157	128,234	214,904
(Mo. River Flood Plain) [2]	(15,763)	(23,322)	(36,804)	(62,284)
Total Tributaries	48,895	76,378	113,036	177,356
Missouri Basin	95,548	152,535	241,270	392,260

[1] Includes drainage areas of less than 400 square miles.
[2] Included in main stems total.

Table 26 – STREAMBANK EROSION DAMAGE WITH CURRENT AND PROJECTED ECONOMIC DEVELOPMENT, MISSOURI BASIN

Subbasin	Total Length of *Channels*	Current Length of *Erosion*	Length of Serious *Erosion*	Average Annual Damages			
				Current	1980	2000	2020
	(Stream-Miles)	(Bank-Miles)	(Bank-Miles)	($ Thousand)			
Upper Missouri	110,700	2,600	460	510	660	930	1,190
Yellowstone	92,700	8,300	2,450	470	620	870	1,220
Western Dakota	107,200	11,700	1,970	454	620	830	1,110
Eastern Dakota	46,000	3,800	870	357	610	830	1,120
Platte-Niobrara	77,700	11,100	1,520	520	800	1,100	1,560
Middle Missouri	33,400	4,900	1,800	1,033	1,540	2,130	2,950
Kansas	26,000	5,200	530	1,287	1,800	2,410	3,220
Lower Missouri	44,300	5,100	1,600	469	650	900	1,230
Missouri Basin	538,000	52,700	11,200	5,100	7,300	10,000	13,600

Table 27 – GULLY EROSION DAMAGE WITH CURRENT AND PROJECTED ECONOMIC DEVELOPMENT, MISSOURI BASIN

Subbasin	Total Area Subject to Damage	Average Annual Damages			
		Current	1980	2000	2020
	(Thousand Acres)	($ Thousand)			
Upper Missouri	Minor	---	---	---	---
Yellowstone	39	281	467	756	1,245
Western Dakota	17	39	53	72	96
Eastern Dakota	126	476	815	1,108	1,497
Platte-Niobrara	97	557	907	1,321	1,976
Middle Missouri	1,053	8,377	12,700	17,759	24,953
Kansas	169	1,075	1,600	2,362	3,570
Lower Missouri	540	4,649	6,869	10,471	17,029
Missouri Basin	2,041	15,454	23,411	33,849	50,366

order to bring conservation treatment and management of the 43 million acres of Federal lands to adequate levels, about 13.7 million acres require the installation of additional conservation measures.

The evaluation of the production capability of the basin showed that 20.2 million acres of pasture and range are arable and exist in large enough tracts to be feasible for conversion to cropland if the need exists. Conversely, 4.6 million acres of cropland should be converted to uses such as grassland to reduce the erosion hazard.

Current farm operations can be improved or land used more intensively on 5.1 million acres of agricultural land by removing the excess water. Of this amount, about 1.9 million acres are cropland and the balance is grassland or woodland.

ENVIRONMENTAL CONSIDERATIONS

Over the years, there has been an increasing concern for the quality of the natural environment, and consideration of its various facets is an important part of the planning process. Among the many problems to be resolved are the intuitive aspects of environmental requirements.

The Missouri River Basin is a large area with an infinite variety of physiographic and vegetative features. There are many ideas of what constitutes a quality environment or what the environmental considerations should be. The concepts range from those advocated by the wilderness enthusiast, who would keep all development or change to a minimum, to those of the farmer, who sees a rippling field of ripening wheat as an ideal environment. "Beauty is in the eye of the beholder."

However, there is general agreement on several primary aspects of environmental quality. The natural landscape, whether it be a natural park, forest, range of mountains, badlands, or prairie, can be used and managed by man to retain much of its original high quality. In the past, this has not been done in many instances and for various reasons, many of which were economic, as in the case of strip-mining or the dumping of raw sewage into streams and rivers. Open, unspoiled spaces of almost any type have an appeal to all, especially the urbanite.

Water, in a natural lake or stream or in a man-made reservoir, has a fascination for the human spirit. It enhances practically all types of landscape environment. The lakes and streams of Yellowstone National Park add greatly to its scenic qualities. Quake Lake improves the scenic values of a unique geological area. The remote lakes and tumbling streams in national forest areas are highly prized. Even when man's activities are not directly related to the water, its presence furnishes a setting that increases his aesthetic gratification.

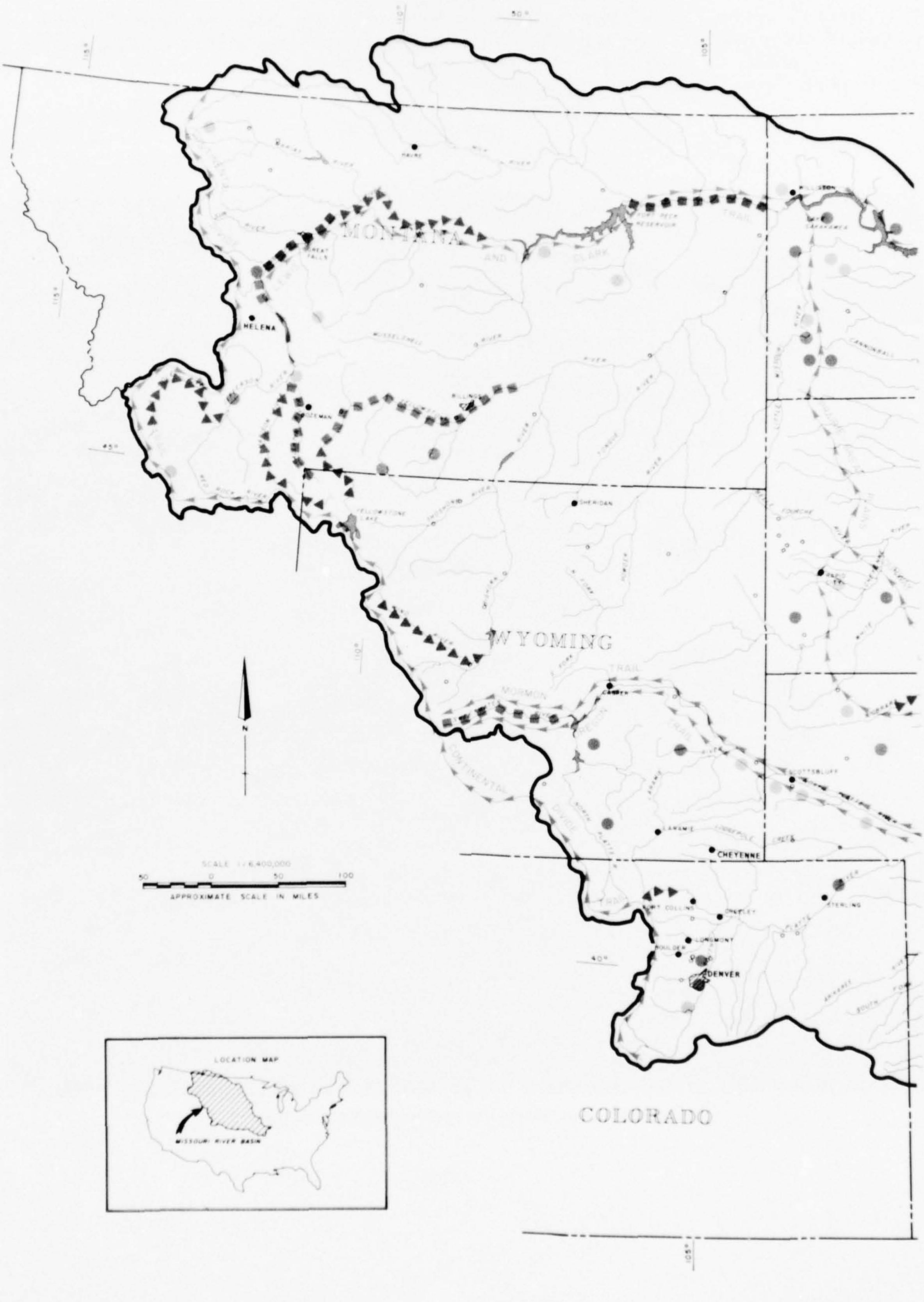
Many of the unique features of the basin such as those of scenic, geological, ecological, or historical importance have been located and are already preserved or are identified in plans for preservation. In the final analysis, it must be remembered that man is part and parcel a resident or visitor to the basin. His changing and varied activities can fit within a socially desirable framework that includes an enhanced environment.

For the purpose of plan formulation, environmental aspects fall into two fundamental categories. One involves amelioration of undesirable environmental conditions and resource developments which contribute to their improvement. This category includes such functions as pollution abatement and water quality control, development of water supply, flood abatement, and improvements for recreation and fish and wildlife enhancement. These potentials have been outlined in preceding paragraphs. It is assumed also that programs for vector control and solid wastes management will be implemented in the future.

The second category involves planning for preservation of the basin's heritage of environmental resources. This category includes an identification of areas of pronounced natural beauty and scenic value, areas of historical interest, and areas of scientific interest. The objective of plan formulation in this latter category is to identify these environmental features by their character and geographic location, to determine those measures

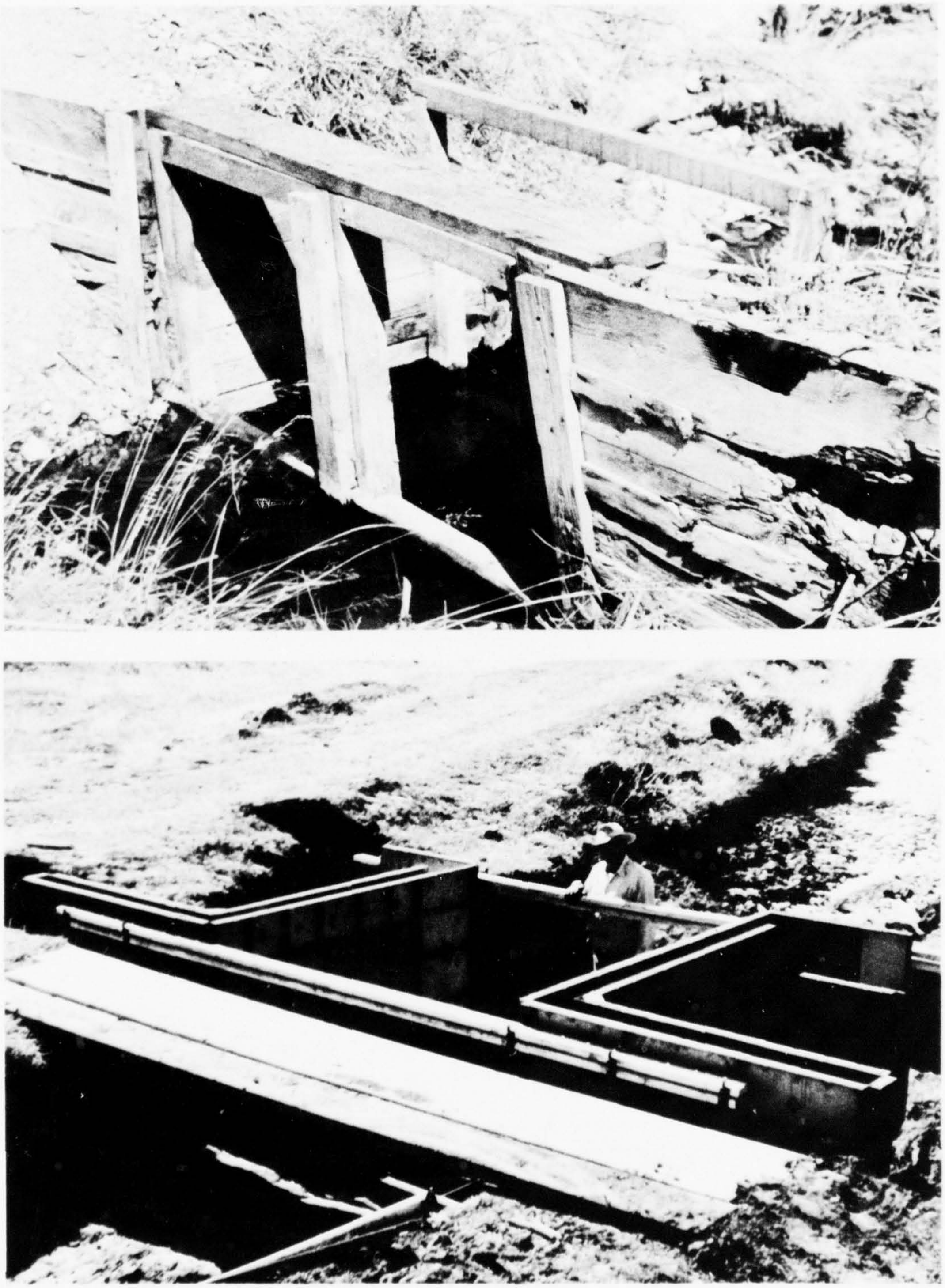
which should be considered for their preservation, and to indicate relative priorities. Since, in terms of a basin-wide perspective, the heritage of environmental features is extensive, such identification is best achieved by means of map illustrations. Figure 17 illustrates by map symbol the character of the basin's major environmental potentials, and their general geographic locations.

Life Giving Sunshine in Rocky Mountain National Park



MONTANA
WYOMING
COLORADO
HELENA
GREAT FALLS
BILLINGS
SHERIDAN
CASPER
LARAMIE
CHEYENNE
FORT COLLINS
GREELEY
LONGMONT
BOULDER
DENVER
STERLING
SCOTTSBLUFF
WILLISTON
HAVRE
LEWIS
AND
CLARK
TRAIL
MORMON
TRAIL
CONTINENTAL
DIVIDE
FORT PECK RESERVOIR
YELLOWSTONE LAKE
MUSSELSHELL
RIVER
N
SCALE 1:6,400,000
50 0 50 100
APPROXIMATE SCALE IN MILES
LOCATION MAP
MISSOURI RIVER BASIN
50°
45°
40°
115°
110°
105°

FIGURE 17
MAJOR ENVIRONMENTAL RESOURCE POTENTIALS



Planning and Action for Betterment — Indian Irrigation Structure

CHAPTER 6

PLAN FORMULATION

PLANNING CONCEPTS

As discussed in chapter 1, framework planning for the Missouri River Basin and its subbasins was oriented to meet three general planning objectives: National efficiency, regional development, and environmental quality. Within this conceptual framework, innumerable alternatives could be considered for attaining the planning objectives. Because of the broad scope of the study and in view of limitations on time and funds, the course of action adopted was to discover as much as possible through the formulation of significant alternatives to various elements of a general overall plan, emphasizing each of the objectives without neglecting the others. Even if an infinite array of alternatives could be formulated, their value would be questionable since they would pose an impossible problem for the public and its representatives in making a choice. Therefore, the alternatives were given a preliminary screening to envolve a plan, and alternatives to certain elements of the plan, emphasizing the three objectives. These preliminary screening studies were made for the subbasins for eventual blending into a basinwide plan. Further discussion on the basis for selection is contained in chapters 7 and 8.

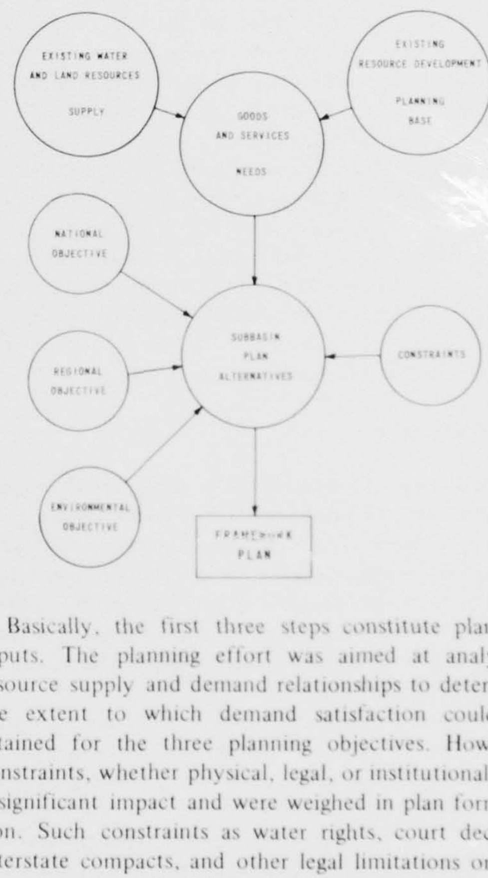
PLAN FORMULATION STRUCTURE

Translation from the planning concepts into a structure for framework plan formulation was accomplished within the limitations imposed by the availability of data. The scope of the planning was dependent on the adequacy and detail of the input data.

Subdivision of the basin into eight subbasins was necessary, not only to simplify the planning procedure, but to recognize hydrologic homogeneity. Having thus simplified the planning process, the sequential planning fell into three general categories of supply, demand, and plan implementation.

The sequential planning process used for formulation purposes, as illustrated in figure 18, included: Inventorying existing water and land resources (supply); identifying existing water and land development (planning base); projecting gross and net requirements for goods and services to be supplied through water and land resource use and management (needs); determining alternative means for meeting requirements oriented to plan objectives (plan alternatives); and selecting the framework plan for the basin (and subbasins).

FIGURE 18
STRUCTURE OF FRAMEWORK PLAN FORMULATION



Basically, the first three steps constitute planning inputs. The planning effort was aimed at analyzing resource supply and demand relationships to determine the extent to which demand satisfaction could be attained for the three planning objectives. However, constraints, whether physical, legal, or institutional, had a significant impact and were weighed in plan formulation. Such constraints as water rights, court decrees, interstate compacts, and other legal limitations on the use of water or land limited the extent to which the demand for certain functional uses could be satisfied. However, the constraints were documented to permit meaningful discussion of possible changes that may be desirable in the future as means for best using the resources physically available, either to attain certain

objectives or to better satisfy demands. Institutional constraints were treated in a similar manner.

The framework study reflects an initial joint Federal-State effort. There was no direct involvement with the local interests except through the State agencies which served as a collection point for any local input. Public meetings were held throughout the basin when the study was nearing completion but there was no real concern expressed. Since the framework plan has not focused on any specific project and is quite general, public concern or debates have not taken place. However, implementation of plans for development of water and related land resources will require active participation by the public and all levels of government. As detailed studies follow the framework study effort, public participation strategies will become indispensable elements of such planning.

PLANNING CRITERIA

With the objectives established for the investigation, plans were formulated based on the current and projected demands for use and management of the water and related land resources. However, planning criteria were required to scale and to compare alternative ways that demands could be met. Functional criteria were based on a consideration of: The amount of resource use to satisfy a demand; adequacy of water supplies in terms of quantity and quality, and the amount of shortage tolerable over a long-term period; the extent of goods and services that would result from any alternate plan element; maintenance or enhancement of environmental factors; and some means for comparing competitive demands for the resources where encountered.

Flood Control

The general criteria adopted for control of floods and the prevention of losses caused by floods recognized the basic parameters of types of areas subject to flood, the amount of average annual flood damage projected over the long term, and generalized probabilities of flooding. The criteria recognized also that flood damage prevention could be achieved to varying degrees by structural and non-structural means.

Structural measures for control of floods were considered to be essential to the economic and social well-being of those urban areas where existing levels of flood damages are relatively high, extensive improvements of the flood plain have already taken place, and a considerable number of people are affected by recurring floods. For these areas, structural measures were formulated to provide, as a minimum, protection against floods having an exceedance frequency of 200 years. If, for economic or physical reasons, the protection target levels could not be attained, a quantitative as well as a qualitative evaluation was made to assess the consequences of actions to implement structural measures providing less than the stated target level of protection. This criteria does not preclude the use of flood plain land use regulation in conjunction with structural measures as a means of limiting future damage levels.

In the urban areas where the flood problem is currently relatively minor, as defined by the parameters previously outlined, non-structural measures would generally be adopted in order to keep the problem from increasing in intensity over the future projection period. However, in some urban areas, it may be more economical and in the best interest of certain communities to intensify the use of floodplains and to provide structural measures, together with some form of flood plain regulation, to minimize flood hazards. For these areas, judgments were made as to the applicability of structural and nonstructural measures.

In agricultural flood plain areas, reduction of flood damages by 50 to 70 percent was considered a reasonable and desirable objective. However, in some special cases, such as high-value agricultural areas, the target damage reduction levels would be dictated by the special considerations. The applicability of structural and non-structural measures in rural areas was determined by such basic indices as value of the areas, flood damages being sustained, and the economic and social need for maintaining these areas at their current productive capability levels, or at some enhanced level.

Generally, control of floods over relatively long reaches of principal streams would be accomplished by reservoir regulation of high flows, but in some instances channelization may be required to meet desirable objectives. In some urban areas, reservoir control would have to be complemented by local protection works, floodplain regulation, or both.

The outputs from developments for flood control and flood damage prevention are measured in terms of annual flood losses prevented, areas protected and managed, and enhancement values created. In relationship to other functional water resource developments, structural measures for flood control would be competitive only with some form of preservation of the existing environment. Management of flood plains can also affect the existing environment. Generally, control of flood flows is nonconsumptive and is, therefore, compatible with all other in-stream functions.

Erosion

Data that give an indication of the magnitude of erosion problems in the basin are limited to general quantification of sediment yields and streambank and gully erosion which are expressed in terms of acres and bank miles affected and damages sustained.

Alleviation of erosion problems would be accomplished by grade stabilization structures, river bank

stabilization and land conservation practices. The extent of these measures required for the various future time frames was determined from a generalized analysis of efficiency gains, and such local impacts as may be significant.

The criteria for gully treatment recognized the productive values of the lands subject to damage, the rate of damage from voiding and depreciation and the size of the problem. Treatment of gullies requiring group or project-type remedial measures is included in this category. Treatment or management for gullies that are stable, progressing at natural or geologic rates, not feasible to treat due to climatic or other reasons, and those treatable by individuals, were included in the land conservation estimates.

In certain areas of the basin, sediment yields are extremely high. Implementation of the measures previously outlined would reduce these yields. In addition, potential reservoirs included in the framework plan were provided with enough storage capacity to contain the sediment delivered to the reservoirs for a period of up to 100 years. A general indication of the reduced sediment transport, for those streams currently having high sediment loads, was determined and judgments drawn as to the enhancing characteristics of the reduced sediment loads on fish, wildlife, recreation, environmental, and other uses.

Land Conservation and Drainage

The general criteria adopted for the adequate conservation treatment and the use of the land and plant resources of the basin included the use of these resources within their capability and treatment according to their need. The minimum treatment standards of Federal, State, and local land management agencies, are based on controlling erosion within limits that will maintain or improve soil resources. These standards provide for maintenance and improvement of vegetative cover to protect the land, and supply acceptable quality water, as well as providing grazing, forestry products, wildlife habitat, and recreation.

The projected rates of accomplishment were based on estimates of the current extent of adequate conservation treatment and remaining needs. Historical trends in applying land treatment and converting land and plant resources to uses within their capability provide the guidelines for the projections.

It was assumed that landowners and operators would continue to apply conservation measures at current rates. It was also expected that Federal and State technical and cost-sharing assistance in planning, applying, and maintaining conservation measures would continue to be made available. Many conservation measures have a life expectancy of 15 to 25 years and it was recognized that re-installation is required to maintain adequate treatment. Other constraints recognized included changes in ownership of private land and unpredictable occurrences such as drouths, diseases, insects, and fire.

The drainage criteria adopted limited consideration to the need for the removal of excess water from agricultural lands only. Other items recognized were the capability of the land, the current agricultural use, the severity of the excess water problems and the extent of the problem area. Project measures servicing groups of landowners and operators were evaluated separately while measures servicing the individual landowner and operator were included in the land conservation programs.

Water Supply

Diversion or withdrawal requirements of surface and ground water for municipal, rural domestic, and industrial purposes, as well as for industries not connected to municipal systems, thermal power cooling, livestock, irrigation, and mineral processing have been projected over the long term. Within the physical and legal constraints applicable in the various subbasins, all facilities and features required for domestic, livestock, and municipal uses would be aimed at meeting the total requirement with minimized shortages within the framework of the constraints. The industrial, mineral, and thermal cooling uses would be supplied to the extent practicable, within physical and legal limitations, options that are available, and tolerable shortages that would not significantly diminish the productive capability of the enterprises involved.

Irrigation

Determination of the availability of surface water for irrigation was based on data from the framework and other studies and from a consideration of other uses of water. Where irrigation or other uses were imposed on ground water, a general appraisal was made on the effects to the ground-water supplies over the projection period.

Water requirements to supply crop needs included a consideration of on-farm losses and transit losses from the point of diversion through the delivery system. Where detailed studies were not available, monthly diversion demands were assumed to approximate 10 percent in May, 15 percent in June, 30 percent in July and August, and 15 percent in September.

Tolerable shortages of irrigation water were adopted from detailed studies that were available. Where such studies were lacking, shortage criteria were based on diversion demands as follows: A maximum shortage of

50 percent in any year; a continuous accumulated shortage not to exceed 75 percent; and an accumulated annual shortage not to exceed 100 percent in any 10-year period.

Planning for new irrigation development was based on a recognition of physical limitations and legal constraints on water availability with a consideration of projected patterns of developments to stabilize and enhance the regional economy.

Water Quality

Attainment of water quality of the basin's streams is aimed at meeting water quality standards as established by the various States. For this study, flow requirements were based on the assumption that effective treatment would be provided for all wastes prior to discharge. The degree of treatment would be equivalent to a biochemical oxygen demand removal of 85, 90, and 95 percent of the future target years of 1980, 2000, and 2020, respectively. Plan formulation studies, therefore, considered the residual flow requirements after treatment. Moreover, other alternatives to streamflow regulation were considered. Diversions and holding ponds illustrate the more probable alternatives, especially for areas where there is not a sufficient water supply to regulate streamflows for water quality control. Therefore, choices were made as to the probable means for maintaining stream water quality standards on the basis of costs, uses of water, legal constraints, and acceptable shortages.

The analysis of alternatives recognized that, as a general rule, consideration would be given to such physical constraints as water yield capabilities and natural channel losses of flow, and to such institutional or unique arrangements that preclude flow regulation as a means for meeting water quality objectives. Also, for Class I and II streams, the classes reflecting fishery values, all quality requirements would be met except when limited by the constraints cited. For Class III and IV streams, quality by flow regulation would not be met except when the stream reach contains a number of water users and the distance is such that wastes from the upstream point would not be assimilated, or where there are significant quantified beneficial uses of the streamflow throughout the reach.

For reservoir operations, acceptable or tolerable shortages of streamflow for quality purposes were based on an index defined as the sum of the squares of annual shortages expressed as a ratio to the annual demand, converted to a 100-year base. A shortage index of 0.25 was adopted for plan formulation purposes. This index represents one annual shortage of 50 percent in a 100-year period, 25 annual shortages of 10 percent, or any combination of annual shortages for which the sum of the squares of the shortages totaled 0.25 in 100 years, or 0.10 in a 40-year base period used in the water supply analyses.

Plan formulation studies considered that water quality to meet adopted standards would be met within the criteria considerations outlined. Insofar as quantifying outputs, other than meeting standards, these could be expressed in terms of population served and stream miles enhanced or preserved.

Recreation, Fish and Wildlife, and Natural Environment

Projections of future demands for outdoor recreation activities and for fishing and hunting were based on demonstrated participation rates of the population in the use of water and land resources. In addition, needs were also outlined for the propagation of fish and wildlife resources and as opportunities for preserving areas for fish, wildlife, aesthetic, cultural, and scientific purposes.

For those features of these functions which are developmental-oriented, the projected requirements would be met through incorporation into multiple-purpose projects and such single-purpose projects, either water or land oriented, as required. As with all other functions, physical and legal constraints were applied as appropriate. Where certain features, especially those that are oriented toward a natural environment, are competitive with other uses of land and water, alternatives were developed to define the degree of competition and the outputs gained or foregone in comparing the alternative choices.

All other items not directly involved with water resource development, or those requiring legal and institutional changes or re-arrangements, were outlined in terms of composition, costs, and future actions required for implementation. For the most part, these items, such as trails, historic landmarks, and general beautification practices, do not and are not affected by a water and related land resource development plan.

COST ESTIMATING CRITERIA

The criteria for estimating the costs of the various elements of the framework plan included those items reflecting group or public action, and items that are a responsibility of the private sector, but reflect significant financial assistance available through Federal grants and loans. The costs presented for the framework plan reflect the first cost of development and no attempt was made to determine investment costs requiring estimates of construction periods and interest rates.

Plan components for which cost estimates were prepared include: Dams and reservoirs and other on-site features; levees, floodwalls, channel improvements, and

appurtenances; single-purpose park and recreation areas covering such features as lands and facilities required; wetland areas including special facilities that may be required; all irrigation developments not covered under reservoirs; municipal and industrial water supply covering the development of supply and treatment works, but not the distribution systems; existing irrigation system rehabilitations; sewage treatment plants, but not the collection systems; wildlife refuges; establishment of wild river or scenic areas; drainage, including the major outlet and interceptor drains; on-farm and public land conservation programs; and for such nonstructural items as floodplain land use management, forest management, and precipitation management. Estimates of annual operation, maintenance, and replacement costs were made for the features cited.

COST SHARING

In order to provide some indication of the general sharing of costs for implementing the framework plan, a broad analysis of this subject was made. It was assumed that existing institutional and legal arrangement would apply for this analysis, although it was recognized that over the projection period these could be modified. In general, percentages were applied to cost items based on broad averages of projects constructed in the past. For single-purpose features, the analysis was straightforward; for multiple-purpose reservoir features, however, very preliminary functional cost distributions were made using the general concepts of the use-of-facilities method. In the application of this method, two general segregations of costs were made: Specific costs identifiable with any given function for the multiple-purpose plan feature were tabulated, and all remaining costs were considered joint. A significant specific cost is ascribed to those additional lands acquired for reservoir features of the plan for the purpose of recreation. It is recognized that these lands serve purposes other than general recreation, such as fish and wildlife and others. In order to simplify the accounting procedures, these costs were assigned to the recreation function. The joint costs were distributed to each of the plan functions by percentages of functional storage requirements to the total storage. Table 28 presents the basic data used for the cost-sharing analysis. Three major components were assumed for this analysis: Features that involve initial Federal investments, those that are non-federally oriented but for which Federal grant funds are available, and programs that are solely non-Federal with no Federal assistance available. It is recognized that for some items the percentages shown would vary under certain conditions. For example, Federal grants for sewage treatment facilities could be as high as 55 percent. There are also other projects which would require initial local financial participation for such items as flood control reservoirs and irrigation rehabilitation, but the degree of this participation is not readily identifiable. However, such refinements are not warranted for this study and should be applied on a project by project basis. Use of the percentage values in table 28 is well within the scope of the study and does provide a general indication of the magnitude of cost-sharing.

BASIN AND SUBBASIN ANALYSES

The formulation of the framework plan, oriented to the multiple objectives, was initially constrained within the eight subbasin boundaries. Such an approach was adopted to simplify the study and to provide meaningful data and information with a manageable geographic area. This approach also permits consideration of any unique local or subbasin goals for program formulation purposes. However, integration of subbasin plans into a basinwide program requires further analyses of the functional interrelationships between the various subbasins. These interrelationships include such items as water-depleting effects, surplus or deficiency of resources in any subbasin to meet its future demands and needs, and possible beneficial or adverse effects on the main stem of the Missouri River. Accordingly, a general analysis of the subbasin plans was made to define the interrelationships outlined, and to determine the consequences of fully implementing any and all elements of the subbasin frameworks.

The Missouri River water resources region, designated the basin, can be likened to a tree, with the eight subbasins constituting the branches and the Missouri River the trunk. A system or network concept was followed for the analysis. Starting at the upper end of the system, and proceeding downstream, the depleting effects of potential subbasin plans on the main stem were determined. Studies were made to determine the extent of subbasin resource surpluses or deficiencies in all functional categories. This type of analysis provides a guide to a potential transfer of available resources, such as water, from a area of surplus to one with a deficiency. Of course, this consideration may involve legal and institutional constraints which must be faced if implementation is to become a reality. It is not the purpose of the plan formulation studies to yield finite recommendations relative to resources transfers or to detail plans for their implementation. Rather, these potentials are presented in broad form with generalized discussions as to implementation. Thus, they provide possible courses of action that can be considered in the future as detailed economic and engineering programs are formulated and designed.

The stream analysis thus proceeds from the upstream end to the mouth of the Missouri River with water depleting effects and consequences of actions assessed both for tributary subbasins and at key points along the main stem.

Table 28 – COST SHARING ANALYSIS FOR FRAMEWORK PLAN
(ALL VALUES IN PERCENT OF TOTAL FIRST COST)

Feature	Plan Features With Initial Federal Investment			Non-Federal Plan Features With Federal Grants		Non-Federal Programs
	Initial Federal	Non-Federal Reimburse.	Initial Non-Federal	Federal	Non-Federal	
MULTI-PURPOSE RESERVOIRS[3]						
Water Quality	100	100[1]				
Irrigation	100	100				
Municipal & Industrial	100	100				
Power (Hydro.)	100	100				
Recreation	100	50[2]				
Fish & Wildlife	100	50[2]				
Flood Control	100	0				
SINGLE-PURPOSE RESERVOIRS						
Flood Control	80		20			
All Others						100
OTHER IMPROVEMENTS						
Navigation	100					
Sewage Treatment				30	70	
Water Supply & Treatment				50	50	
Land Conservation						
Private				50	50	
Public	100					
Erosion Control						
Streambank	70		30			
Gully	80		20			
Flood Control						
Local Protection	80		20			
Flood Plain Management						
Technical Assistance	100					
Implementation						100
Irrigation[3]						
Private						100
Public	100	100				
Rehabilitation	100	100				
Group Drainage	50		50			
Recreation						
Multi-Purpose Development	50		50			
State & Local				40	60	
National Recreation Area	100					
Scenic Rivers	100					
Trails	100					
Fish & Wildlife						
Refuges	100					
Wetlands	95		5			
Management Areas				50	50	
Fish Hatcheries	50		50			
Fish Impoundments	50		50			
Access						100
Water Yield						
Forest Management	100					
Precipitation Management	100					

[1] All costs are non-reimbursable if benefits are widespread.
[2] Fifty percent of separable costs.
[3] Costs will not be 100 percent Federal when projects are installed under authorities which require initial local financial participation.

CHAPTER 7

FRAMEWORK PLAN

The regional framework plan was derived from the formulation of tributary subbasin plans. Planning in the subbasins considered the natural attributes of each area, needs and demands to be met in support of the projected future economy, economic and social objectives that in some instances went beyond base-line economic projections, and such physical, legal, and institutional constraints as were applicable. Therefore, the formulation of the regional framework plan required an assessment of each subbasin framework plan in light of the considerations cited and analyses of the effects of water and related land resource developments in the subbasins on the Missouri and Mississippi rivers.

The elements and features of the total framework plan in each subbasin have been grouped in three general categories. These are: (1) specified non-Federal programs and modifications or additions to existing water and related land developments; (2) water control and related land development; and (3) environmental enhancement and non-structural measures. Specified non-Federal programs as used in this study are those developments that are implemented by State and local governments and the private sector and which include: Ground-water irrigation developed or improved by individual farmers with limited Federal financial and technical assistance available; recreation development such as parks, swimming pools, golf courses, and others carried out by States, other local governmental units, and the private sector with Federal financial and technical assistance available through such grant programs as the Land and Water Conservation Fund; and the land conservation program on private lands, which has been a part of a coordinated public and private effort dating back to the 1930's (Federal financial and technical assistance provided to individual farmers).

Modifications or additions to existing developments include improvement or rehabilitation of existing irrigation systems, either federally or privately constructed; structural or managerial modifications of existing Federal or non-federally constructed reservoirs; provision of recreation and fishing access to existing areas that can provide for uses cited; and modification of existing refuges and fish hatcheries. The items outlined would be implemented only if they are the most economical means for providing goods and services stemming from the modifications.

The water and related land development features of the framework plan encompass those major public works programs normally undertaken in response to congressional authorizations and in cooperation with States and local interests. Some essentially single-purpose water control features, such as irrigation using surface water supplies, will be carried out by the State, local, and private sectors. Costs associated with such developments have been included.

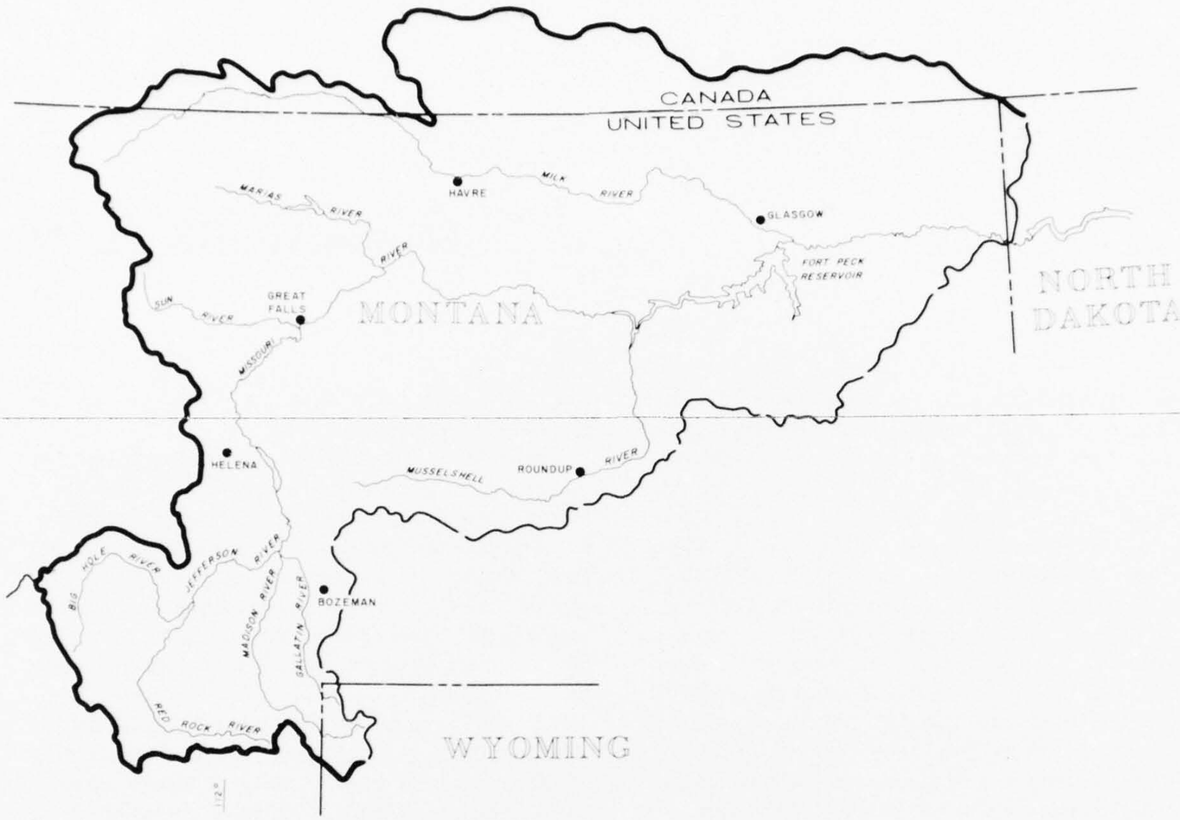
The environmental and non-structural features of the total framework plan are those normally implemented by States and local interests, although Federal financial and technical assistance is available. However, some items, such as national refuges and wetland preservation, are Federal programs carried out in cooperation with States and local interests.

UPPER MISSOURI SUBBASIN

The Upper Missouri Subbasin includes all of the streams tributary to the Missouri River above its confluence with the Yellowstone River. Of a drainage area of about 92,500 square miles, about 9,700 square miles are in Canada. The latter area is not treated in this study, except from a water accountability standpoint.

Water Resources

Annual precipitation in this semi-arid region ranges from as much as 25 inches in the mountains to 8 inches on the plains. The streamflow pattern is characterized by high annual runoff for mountain-based streams and much lower runoff for prairie streams. Annual runoff ranges from about 20 inches in the mountainous areas to as low as 0.5 inch in the prairies. However, the precipitation and runoff are extremely erratic; in wet years it may be 2 to 2-1/2 times the mean annual volume and during dry cycles as small as 20 to 50 percent of normal. It is not uncommon for the western mountain streams to experience 75 percent of annual runoff in the months of May and June with peak discharges of 10 to



15 times the average annual discharge. In the late fall and winter, flows may drop to as low as 10 to 15 percent of average. At the present time, 135,000 acre-feet of water are imported to the Milk River from the St. Marys River in accordance with an international treaty.

In the eastern, more arid portion of the subbasin, where surface-water resources are sometimes undependable, ground-water use is more prevalent and is generally confined to livestock, rural domestic, and municipal use. In the western valleys, both quantity and quality of ground water are better and depths to reliable aquifers are less than in the eastern part. Withdrawal rates are higher but still not extensive, primarily because of the economic availability of good quality surface waters. Ground-water pumpage throughout the subbasin for all purposes has increased from 71,000 acre-feet annually in 1955 to 102,000 acre-feet in 1965.

Quality of surface-water resources is generally good to excellent, but waste treatment facilities need improvement and expansion throughout the subbasin. There are 95 central water systems within the subbasin that serve 215,000 people, which is 72 percent of the 1960 population. Of this number, 80 have sewerage systems, with 14 providing primary treatment only and 66 have secondary treatment plants. Various industries connected to these systems increase the total wasteloading to 430,000 population equivalents before treatment. Existing treatment plants reduce the waste load to 228,000 P.E., most of which is discharged to streams of the subbasin. Some of the urban places are located on divides and many others are near streams that flow only intermittently. A number of communities on the plains have built sewage lagoons which are adaptable to the area and usually there is no discharge from them.

Mining activity and the milling and processing of ore near East Helena, Mont. have created some waste disposal problems. Wastes from oil and gas fields, now under strict surveillance, are exceptionally low in chlorides, but high in sulfates.

Fisheries in five stream reaches totaling over 125 miles are known to be adversely affected by municipal and industrial pollution. These include the Missouri River, East Gallatin, and Spring Creek, though other reaches also are adversely affected.

Suspended sediments are generally of small concern because of low yields from watersheds; yet, local problems do occur which adversely affect quality at certain times of the year and for certain purposes. Sediment yield rates range from 0.03 acre-foot per square mile annually from watersheds in the forested mountain areas to as much as 0.15 acre-foot per square mile in the eastern plains section of the subbasin.

In the eastern part of the subbasin, ground-water quality is generally poor for most uses with total dissolved solids as high as 4,000 mg/l. High concentrations

of chlorides, sulfates, and iron are found at many locations and in most aquifers except in alluvial sand and gravel deposits along stream courses.

The dissolved solids concentration in the streamflow leaving the subbasin average about 430 mg/1. This concentration results from salts in the natural runoff plus those in the return flow from 1.1 million acres of irrigation and in the municipal and industrial effluents.

Flood and Erosion Control

Existing improvements include three local protection projects, two upstream watershed projects, and four reservoirs which provide flood protection to about 180,000 acres. A total area of 850,000 acres is now subject to flooding, of which 340,000 acres are located along the main stem of the Missouri River. In addition, urban flood damages have been incurred at 20 communities with a total 1960 population of 80,000. Historically, damaging floods have occurred with recurring frequencies of 5 to 10 years, although some damage is experienced more frequently in certain areas. Main stem flooding downstream from Great Falls is not economically significant.

Floods at Great Falls, Montana Remain Uncontrolled

Without existing flood control measures the total damages under current economic conditions would be $2,307,000 annually. Existing improvements reduce these to $1,517,000. Of the estimated current annual damages, about 7 percent occurs along the flood plain of the Missouri River, the most severe problems being along the tributaries.

Streambank and gully erosion problems are localized. Relatively low bank erosion rates have been experienced along most streams with only about 460 bank-miles, or 0.2 percent of the existing channel banks, having serious erosion. However, under current conditions, average annual losses due to streambank erosion are estimated to be $510,000. In general, gully erosion has not been of a significant magnitude to warrant project-type preventative action.

Water Supply

Both ground and surface waters are being withdrawn for domestic, industrial, and agricultural uses. The emphasis, however, has been on surface supplies. The subbasin has experienced a long history of irrigation development beginning in the 1860's. Expansion and growth have been erratic, depending on the agricultural economy, the growth of the livestock industry, and the availability of adequate planning and financing to permit construction of irrigation facilities.

In recent years, ground-water pumping was started to supplement surface-water supplies for irrigation and to implement new concepts of water application by means of large sprinkler systems. Such systems, however, represent only a small percentage of the total irrigation works.

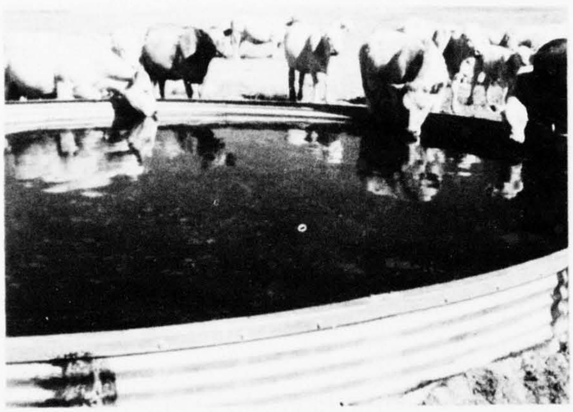
At the present time, 1,102,000 acres are irrigated on a regular basis with full water supply and full agricultural production. In addition, over 400,000 acres are irrigated on an intermittent basis each year, or from year to year, depending on the availability of water from storage, variable stream runoff, or the inclinations of the landowner. Much of the irrigated land is used for feed grains, alfalfa hay, wild hay, and pastures to support livestock operations. Sugar beets and potatoes are also significant cash crops. The effect of irrigation on the agricultural economy is very important as a stabilized source of feed for the livestock industry.

To achieve the present levels of irrigation development, storage works with a total capacity of 775,000

Irrigation of Potato Fields Is Profitable

acre-feet, exclusive of Missouri River storage, have been constructed and 19,600 miles of main canals have been built. Many existing canals need improvement and rehabilitation, drainage works are required, and improved irrigation practices would enhance efficiency and production.

Livestock water is provided by wells and surface sources, 37 and 63 percent, respectively. Present use amounts to 22,000 acre-feet annually. Use of water by livestock comprises a fairly small portion of all water requirements and no problems are currently being encountered or anticipated in the future.

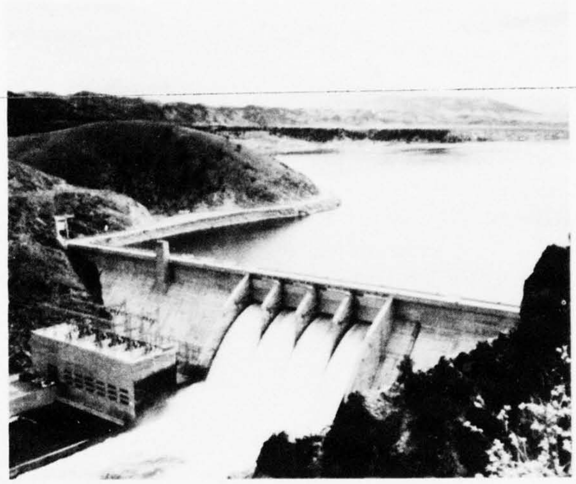


Livestock Water Is Essential In The Range Country

Since there are no thermal-electric generating plants in the subbasin, the remaining principal water uses are for domestic, municipal, and industrial purposes. The gross withdrawals of water for these purposes approximated 115,000 acre-feet in 1965. Communities in the eastern and northern part of the subbasin which rely on ground-water supplies are presently contending with poor quality water because of high concentrations of iron, fluorides, chlorides, and sulfates. If better quality water could be made available at a reasonable cost, the communities involved would seek and would be able to support such improvement. Even some surface supplies are not now being adequately treated and improvement is needed.

Electric Power Generation

Since no thermal plants have been constructed in the subbasin, electric energy is being supplied from 10 hydropower installations. These have a total installed capacity of 472 megawatts. The opportunities for additional hydroelectric plants appear to be limited, and utilization of some of the desirable sites still left would undoubtedly conflict with recreation, fish and wildlife, scenic rivers, or other environmental objectives. Insofar as thermal generating plants are concerned, the eastern portion of the area contains large reserves of subbituminous coal and lignite for fuel, and the Missouri River below Fort Peck Dam can provide ample quantities of water for condenser cooling without significant thermal pollution.



Hydroelectric Power Is One of the Multipurpose Functions of the Canyon Ferry Dam and Reservoir Near Helena, Montana

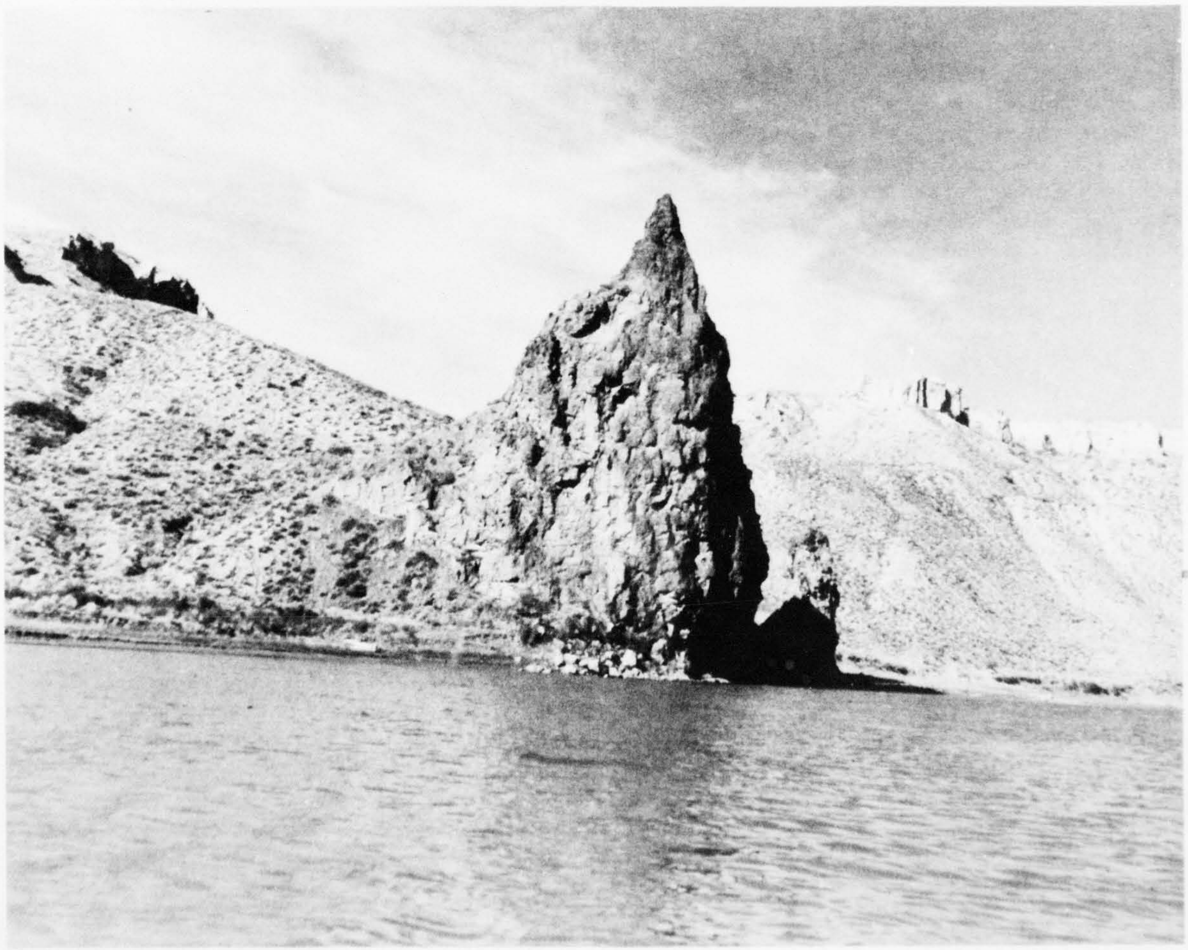
Fish, Wildlife, and Recreation

Creation of opportunities for water-based recreation and development of fish and wildlife habitat have always been important aspects of water resource utilization in the subbasin. At the present time, virtually all of the 669,000 surface acres of water area in the subbasin are useful to fish and wildlife, and wildlife uses nearly 52,000,000 acres of the total land area of which about 3,500,000 acres are devoted primarily to wildlife use. These existing resources provide fishing capacity nearly six times the current demand and hunting capacity about double the present use. The need for higher quality hunting or fishing or for waterfowl production areas (wetlands) may not, however, be met by the present developments. Demands from outside the subbasin or depreciation of the existing capacity may require certain specific single-purpose or multi-purpose projects for fish and wildlife. Resources needing particular attention are the 4,400 miles of classified fishing streams of which 254 miles are Class I (national importance), and 308 miles are Class II (statewide importance).

The subbasin is a favored area also with respect to other forms of outdoor recreation. It contains portions of two of the most important recreation attractions in the region, Yellowstone and Glacier National Parks,

thousands of square miles of scenic mountains and valleys, and hundreds of miles of top quality trout streams. Recreation areas have been classified as scenic, historical, or natural, Type I; land-oriented, Type II; or water-oriented, Type III. In total, 12 Type I, 152 Type II, and 139 Type III areas have been inventoried. No estimate has been made of the number of land-oriented private recreation areas but their numbers and importance are substantial. Nearly 92 percent of the total recreation lands and half the developed acreages are in federally administered areas. The 15 Federal reservoirs are fairly evenly distributed throughout the subbasin and, along with private irrigation and power reservoirs, provide more water-based recreation capacity than the total current demand. Except for fishing, very few tourists come to the area to engage in water-oriented activities.

The Missouri River from Fort Benton, Mont., to the headwaters of Fort Peck Reservoir has been recognized for its unique scenic qualities. By proclamation of the Montana State Game and Fish Department, this reach of the river has been designated a free-flowing waterway. Also, this reach was included in recent legislation to be studied for possible inclusion in the National Wild and Scenic Rivers System.



Cathedral Rock Is Typical of the Scenic Qualities of the Missouri River Above Fort Peck Reservoir

Land Conservation and Drainage

Currently, 10.7 million acres of the privately owned lands in the subbasin are used for crop production, 25.5 million acres are used for pasture and range, 2.0 million acres are in forest and woodlands, 200 thousand acres are in other agricultural uses, and 632 thousand acres are in non-agricultural uses. About one million acres of cropland and 149 thousand acres of pasture and range are irrigated annually. An additional 418 thousand acres of land receive intermittent applications of irrigation water. About 11.9 million acres of Federal land are used

for agricultural purposes, 8.1 million are grazed and 5.2 million produce forest products. An additional 1.3 million acres of Federal land are used for non-agricultural purposes.

Of the 10.7 million acres used for cropland, 93 percent, or 10 million acres are suitable for sustained cultivation with proper management and conservation measures. The remaining seven percent or 657 thousand acres of cropland are not suitable for continuous cultivation without sustaining damage to the soil resources. Conversely, about 3.9 million acres of pasture and range are physically suitable and can be used for sustained crop production with proper management and conservation measures.

Wind and water erosion seriously affect lands in the subbasin. Through their own efforts and with Federal technical assistance and cost-sharing available to them, the owners and operators have installed adequate conservation treatment and management on 15.7 million acres of the private lands. Management-type practices on 19.4 million acres and mechanical or vegetative-type practices on 4.1 million acres are needed to provide adequate levels of conservation treatment and management.

On federally owned lands, 64 percent, or 8.5 million acres are currently adequately treated and managed. The remaining 4.7 million acres in the subbasin need improved conservation treatment and management for sustained use without deterioration.

There are approximately 885 thousand acres of agricultural land in the subbasin subject to excess water problems. This is exclusive of 79 thousand acres of land within current irrigation systems which also have an excess water problem. Currently, 101 thousand acres of cropland have been provided with adequate drainage. Of the remaining 784 thousand acres subject to excess water, 320 thousand acres are considered potentially suitable and feasible to drain. Less than one percent of this area is currently cultivated and current use would be improved by allowing timely operations. An additional 313 thousand acres of pasture and range and seven thousand acres of forest and woodland are subject to problems of excess water and are suitable for conversion to cultivated uses. There are no group drainage needs in this subbasin.

About 458 thousand acres, or 52 percent of the land with excess water problems are considered infeasible to drain. Of this total, eight thousand acres are currently used for cropland and should be converted to non-crop uses. This and the remainder should be used for grazing and woodlands and managed to utilize its natural value as wildlife habitat.

Planning Objectives

The subbasin is a sparsely populated area. With less than 300,000 people in 1960, the population density was less than four persons per square mile. Historical economic trends show that the area generally has followed the regional trends of declining rural population and absolute population growth significantly less than the national average.

Industrial development, other than agricultural production, has been extremely limited. This is attributed to distances to large-scale markets and the absence of natural resources that could be economically processed. It is anticipated that traditional industrial growth will not take place to any great extent in the future.

The major attributes of the subbasin are its vast agricultural lands, relatively clean waters, national parks and forests, beautiful lakes and reservoirs, and its relative abundance of big game and prime trout fishing waters. The major problems of the area are economic in character. Lack of employment opportunities has led to significant out-migration with only partially offsetting population gains in the few urban centers. Although a significant recreation potential does exist, the industry suffers from seasonality which reflects the climatic characteristics and types of recreational opportunities. Similarly, agriculture is affected because of the semi-arid characteristics of the area and the inability to significantly increase agricultural production, principally livestock. The socio-economic problems, therefore, can be attributed generally to space – low densities of use of the land, limited opportunities for capital intensification, and a narrow supporting base for increases in population and real income. At the same time, the residents of the area require the services demanded by a modern society – government, schools, medical care, and other social necessities and amenities.

In view of the foregoing and within the multiple objective concept adopted for planning, the major goals for development of water and related land resources for the upper Missouri area are an intensification and increased economic efficiency of the agricultural base and preservation, development, and management of its environmental attributes for the development of an economically viable recreation industry. Within the agricultural sector, irrigation will probably have to be expanded if livestock and livestock feed production are to be significantly increased. Irrigation coupled with land treatment measures, development of farm ponds, improved agricultural practices, erosion control, drainage, and flood control offer an opportunity for some economic growth and higher efficiencies in land use. From an economic standpoint, the development and use of the environmental opportunities of the subbasin will depend on the attractiveness and uniqueness of these opportunities, the extent to which they are

promoted successfully, and the health of the subbasin's economy for supporting a flourishing recreation industry.

Specified Non-Federal Programs and Modification of Existing Developments

Potentially irrigable lands in the subbasin total about 7 million acres. The present irrigation is being accomplished solely with surface water supplies. An analysis was made of the potential for ground-water irrigation, which considered such factors as water availability, land suitability, the ability and willingness of individual irrigators to assume the costs associated with such development, and the need for such development in response to the regional planning objective. It indicates that irrigation, through the use of ground-water supplies by the private sector, would be limited and would approximate 55,000 acres through the projection period and probably would be initiated sometime after 1980.

Recreation development by the State, local, and private sectors includes the lands and facilities necessary to meet projected future needs. No constraints were placed on the extent and magnitude of such development, which in the Upper Missouri Subbasin requires the development of 656,000 acres of land for recreational uses.

The land conservation program is inexorably associated with the total framework plan and reflects a continuation of the activities carried out under this program at a rate approximating historical application.

Various other opportunities exist in the subbasin for increasing the goods and services from the use of water and land resources by modifying existing developments. Existing irrigation systems can be combined, improved, and rehabilitated as a means for conserving water, reducing operation and maintenance costs, and for stabilizing and increasing agricultural production. Using economic efficiency as the principal criterion, about 2,200 miles of irrigation ditches should be consolidated, better than 1,000 miles of ditches lined, and associated agricultural drainage improved on 79,000 acres. Since irrigation in this subbasin is and will continue to use predominantly surface supplies, structural modification to the existing Durand and Ruby reservoirs to increase storage capacity by 30,000 acre-feet offers an economical means for meeting a part of future irrigation expansion.

From a recreational and environmental standpoint, enhancement of wildlife and fish production can be obtained by modifying three existing refuges and one fish hatchery. Although an overall excess capacity of surface water exists for recreational use, especially fishing, provision of access to about 95 potential use areas can improve quality and tend to correct some locational disadvantages. Table 29 summarizes the measure of the physical features of specified non-Federal programs and modifications to existing developments included as part of the total framework plan.

Water Control and Related Land Development

The magnitude of the elements of the plan for water control and related land development depends on the extent to which each of the planning objectives is stressed through alternative courses of action. To assess the differences between developmental plans and opportunities and those that emphasize the environmental objective, plans were formulated stressing each. It is recognized that extreme viewpoints could be embraced, ranging from maximum to minimum water control. However, only potential conflicts for use of the resources which were significant were delineated for plan formulation purposes.

Within the context of the foregoing, plans of water systems which include control of surface waters by

Table 29 – SPECIFIED NON-FEDERAL PROGRAMS AND MODIFICATIONS OF EXISTING DEVELOPMENTS, FRAMEWORK PLAN – UPPER MISSOURI SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SPECIFIED NON-FEDERAL PROGRAMS				
Private Ground-water Irrigation	1,000 AC	0	30	55
State, Local, and Private Recreation	1,000 AC	246	457	656
Private Land Conservation	1,000 AC	4,587	10,243	15,596
MODIFICATIONS OF EXISTING DEVELOPMENTS				
Irrigation System Improvements				
Ditch Consolidation	Miles	657	1,527	2,183
Ditch Lining	Miles	319	736	1,057
Drainage	1,000 AC	24	55	79
Reservoirs	1,000 AF	0	10	30
Fishing & Recreation Access	Number	16	42	95
Fish Hatcheries	Number	1	1	1
Refuge Additions	Number	1	3	3

reservoirs as well as by in-stream structures and associated land development features were formulated. In response to the national-regional planning objective, reservoirs having a total storage capacity of slightly more than 12 million acre-feet would be required. For the environmental objective, total storage would be reduced to about 2.4 million acre-feet. Since local protection and bank stabilization structures are responsive to all planning objectives, no apparent conflicts exist. These features include about 20 miles of local protection structures and 144 miles of bank stabilization works.

Associated land development programs include provision of developed and undeveloped lands for general recreation and fish and wildlife, surface water irrigation, and land conservation practices on federally owned lands. Within the national-regional objective, 38,000 acres of land would be provided for general recreation and fish and wildlife while for the environmental objective an increase of 844,000 acres would be required. Similar comparisons for irrigation would be 495,000 acres and 363,000 acres. Land conservation practices on federally owned land would be compatible with all planning objectives and would approximate 3.9 million acres over the projected period. Table 30 summarizes the physical composition of the water control and associated land development features formulated in response to the planning objectives.

Table 30 – WATER CONTROL AND RELATED LAND DEVELOPMENT, NATIONAL-REGIONAL AND ENVIRONMENTAL OBJECTIVES – UPPER MISSOURI SUBBASIN

Feature	Unit	National–Regional Objective			Environmental Objective		
		1980	2000	2020	1980	2000	2020
		(Cumulative Above Current)					
SURFACE WATER CONTROL							
Storage	1,000 AF	1,819	11,344	12,126	1,237	1,932	2,487
Local Protection	Miles	17	20	20	17	20	20
Bank Stabilization	Miles	36	108	144	36	108	144
LAND DEVELOPMENT							
Recreation, Fish & Wildlife	1,000 AC	15	25	38	677	764	844
Surface Water Irrigation							
Federal[1]	1,000 AC	192	377	495	143	252	363
Public Land Conservation	1,000 AC	773	2,712	3,870	773	2,712	3,870

[1]Exclusive of 274,000 acres of presently irrigated land to be provided with supplemental water and facilities.

A wide range of alternatives for use and management of the water and related land resources is available in the Upper Missouri Subbasin. In order to guide the selection of a framework plan for this area, a discussion of the principal areas of conflict and the social and economic effects that can be expected for given courses of action is required. The following paragraphs discuss these considerations by planning areas within the subbasin.

The Big Hole River area, located in a scenic mountain area in the upper portion of the subbasin, has some unique aesthetic qualities due to its scenery and quality of its waters. The lower 50 miles of the river has been classified by the Montana Fish and Game Department as a "Blue Ribbon" trout stream. Sportsmen groups and conservation organizations propose that this stream be preserved in its current state.

However, this river has some other characteristics that are not so attractive. Spring floods occur almost annually, damaging property locally as well as downstream in the Jefferson River drainage. During highwater periods, many times extending into July, the Jefferson River, characteristic of snow fed mountain streams, is practically unfishable. The river also is subjected to low-water periods when it becomes practically dewatered, especially when private irrigation withdrawals are heavy. Although fish production may be reduced by low flows, fishing often is enhanced. There is a need for stream regulation in order to control flood flows and for water supply uses which do not degrade the fishing and would be compatible with and enhance the environmental characteristics. Reservoir storage in the Big Hole basin would provide a reasonable amount of flood protection, water for the irrigation of 64,000 acres of land, and streamflow regulation of nearly 100 miles of the Big Hole and Jefferson rivers, thus enhancing the fisheries and other environmental characteristics. Insofar as scenic area preservation is concerned, about 20 miles of stream would be affected, 11 miles of this by reservoir inundation. Substantial enhancement to the fisheries and wildlife downstream would be realized from this multiple-purpose storage development.

In the Sun River area, basic conflicts arise between possible developmental programs for flood control, irrigation, streamflow regulation, fish and wildlife, and outdoor recreation. The existing Sun River irrigation project has about 18,000 acres of land currently undeveloped because of the lack of a reliable water supply. In addition, approximately 30,000 acres of new land could be irrigated if water were made available. Relatively severe floods are a problem throughout the length of the Sun River, culminating in the major urban damage center of Great Falls at the junction of the Sun

and Missouri rivers. Although a high degree of flood protection will be provided at Great Falls by means of a local protection project authorized for construction by the Corps of Engineers, flood protection upstream from the city can best be provided through reservoir control of high flows. The most logical sites for control of both high and low flows are in the mountainous areas below the junction of the North and South Forks of the Sun River. Multiple-purpose storage at that location would provide substantial flood damage reductions, provide for enhancing and expanding irrigation in the general area, furnish a stream regulation regime that would eliminate periods of high and low flows, thus insuring better quality of water conditions plus use of the river downstream and at the existing Willow Creek Reservoir for fish and recreation purposes. However, the probable operation of the reservoir would largely preclude pleasure boating, swimming, and water skiing activities. Also road access would be extended only to the dam, and the reservoir area would have access by trails only. Thus the impoundment would have minimal recreation value.

Gibson Reservoir On the Sun River in Montana Provides Water For Irrigation

The storage potential outlined would, however, have serious adverse effects on the Bob Marshall Wilderness Area. The Forest Service has estimated that construction of Lower Sun Butte Reservoir would require declassification of about 50,000 acres of the Bob Marshall Wilderness Area to maintain its integrity as wilderness. Within the potential reservoir area, the possible effects on elk and Rocky Mountain Sheep could be significant. Since the big game herds depend on the range in this area for their continued welfare, and since the wilderness area is by law to be inviolate against intrusion, reservoir proposals will meet with vigorous opposition. There is no question that potential reservoirs would conflict with the intent of the Wilderness Act of 1964 and interfere with traditional big game migration routes and habitat, but the ultimate effects on the herds is not known. Whether the animals could adapt to a changed environment, or whether certain mitigation measures could be

undertaken to insure adaptability, will require further detailed study.

An alternate reservoir site has been studied which would be located downstream in the plains area, yet well upstream from Great Falls. It would provide values for the correlative functions of outdoor recreation and fish and wildlife enhancement treble those of the upper sites, an equal flood control potential, and an irrigation potential one-third that of upper Sun River sites. However, based on the studies to date, the lower reservoir appears infeasible because of higher costs and a substantial reduction in irrigation potential.

This situation poses a paradox. Development of the water supply from the upper Sun River appears to offer many beneficial advantages for the general area and is feasible where three-fourths of the values are to irrigation. However, while there have been expressions of interest in the need for conservation of the water for future irrigation, currently there is no strong unified interest identified for irrigation among the potential water users. The lower site, while more acceptable from the environmental viewpoint, currently shows engineering and economic infeasibility. This, taken together with the opposition to upper Sun River storage, makes it necessary to defer a decision until the needs become more impelling and the interests better defined for conservation of the water and related land resources in the Sun River area. A final decision can only be made following more detailed appraisals of the effects of potential reservoir developments on the wild game herds and fishing, of other intangibles in the present identification of needs and values, and of the broad public interest in actual development.

Smith River and Belt Creek are two streams with relatively simple problems for which alternatives are available. Both occupy scenic canyon reaches with unique recreational and fishing characteristics. They have been designated by the State of Montana as trout streams having state-wide importance. Also, the State has recommended establishment of a recreation waterway on the Smith River through the canyon area to be managed similar to other national scenic rivers.

Recurring flood problems on these two streams range from minor to moderate, and a need does exist for regulation of water supply for limited irrigation and minor water quality problems. However, in view of the actions taken by Montana with regard to these streams, the aesthetic qualities of the area, and the relatively minor needs for development of the water resources of these streams, an environment-oriented plan and management thereof is considered a logical course of action to follow in the future.

The Madison River has the same highly desirable scenic and fishing characteristics as the Big Hole River. It is highly prized and renowned for its trout fishing. About 135 miles of the stream between Three Forks and Hebgen Dam have been proposed for designation as a scenic river. From a developmental standpoint, about 33,000 acres of irrigation can be supplied from direct streamflow diversions. Because storage works are not needed and water supplies are generous, conflicts in water use adversely affecting the fabulous fishery may not occur. More detailed studies are required to establish whether diversions could be made without depreciating this important fishery. The segment of the Madison from Quake Lake to Ennis Lake has been identified under Section 5(d) of the Wild and Scenic Rivers Act. As discussed earlier, the free-flowing potential of these rivers must be evaluated and included as a specific part of any Federal planning report as a potential alternative use of the water and related land resources.

There are several resource potentials and certain basic conflicts as concerns the developmental programs for the 125-mile reach of the Missouri River between Fort Benton and Fort Peck Reservoir. These potentials involve, on one hand, the construction of structures to regulate the flow for hydroelectric power generation and other uses, and, on the other, major primitive environmental considerations for a free-flowing river.

Recognizing the significant aesthetic, cultural, and historical values, the Montana State Game and Fish Department has designated this reach as a free-flowing recreation waterway, although this reach of river is not, in the true sense, a free-flowing waterway. In the Wild and Scenic Rivers Act of 1968, that segment of river from Fort Benton to Ryan Island was designated for added study and potential addition to the national Wild and Scenic Rivers System. In its present semi-natural or wild state, the area is relatively inaccessible, and each year provides a limited number of people with an unique type of recreation experience. The natural recreational characteristics found here probably cannot be duplicated elsewhere. Preservation of the reach would leave the area in an essentially natural state, but in essence provide an outdoor museum of unique interest to many people.

This reach of the river also provides a significant opportunity to develop the entire water supply to serve several purposes. With appropriate storage regulation of the water supply and a potential head of about 370 feet, peaking hydropower plants with an installed capacity of 814 megawatts could be developed. Also, such development can provide an opportunity to divert some water to the water-short Milk River drainage to the north for irrigation and related development. Storage in this reach of the river would have to be integrated with the downstream main stem reservoir system for multiple use. There are divergent views as to the effects that dam and reservoir construction would have on this reach of the river. Obviously, it would inundate the relatively narrow valley and parts of the cliffs and canyons prevalent throughout the reach. However, considerable access to the area would be made available and probably more

people would visit and view the scenery in using the lakes for recreational pursuits. There is a potential also for reservoir storage at the head end of the reach to regulate streamflows for uses indicated and to stabilize flows in the 125 mile reach. Such a reservoir would have no serious physical conflicts with the stated objectives of the Wild and Scenic Rivers Act.

The Scenery On the Missouri River Above Fort Peck Is Striking

Further detailed studies are required to establish the needs for additional upstream storage within or at the head of this reach of the Missouri River to operate as a part of the overall system, including firmer conclusions on the financial feasibility of hydropower generation. Recognizing the conflicts and alternatives, a choice of action cannot and probably should not be made at this time. An in-depth analysis of all possible alternatives should be made in the future, utilizing all presently known potentials and additional data developed that would provide a widespread public awareness and response to the alternatives. Pending such studies and analyses, nothing should be done in this reach of the river, meanwhile preserving its existing environmental characteristics. Under the Wild and Scenic Rivers Act, there is the directive for a comprehensive study and report to the Congress on several potential national and scenic rivers, including this reach of the Missouri River, within a period of 10 years, or not later than 1978. Under an earlier directive of the Congress, a recreation resources study was completed in 1968 and among the proposals recommended was the designation of this general reach as the "Missouri Breaks National River."

The Missouri Breaks is a land area of rough canyons, coulees, and ridges adjoining both sides of the Missouri River downstream from the mouth of the Judith River, but excluding the narrow area considered for designation as the Missouri Breaks National River. This is about the lower-half of the river reach already described. The Missouri Breaks area, which extends about 20-30 miles

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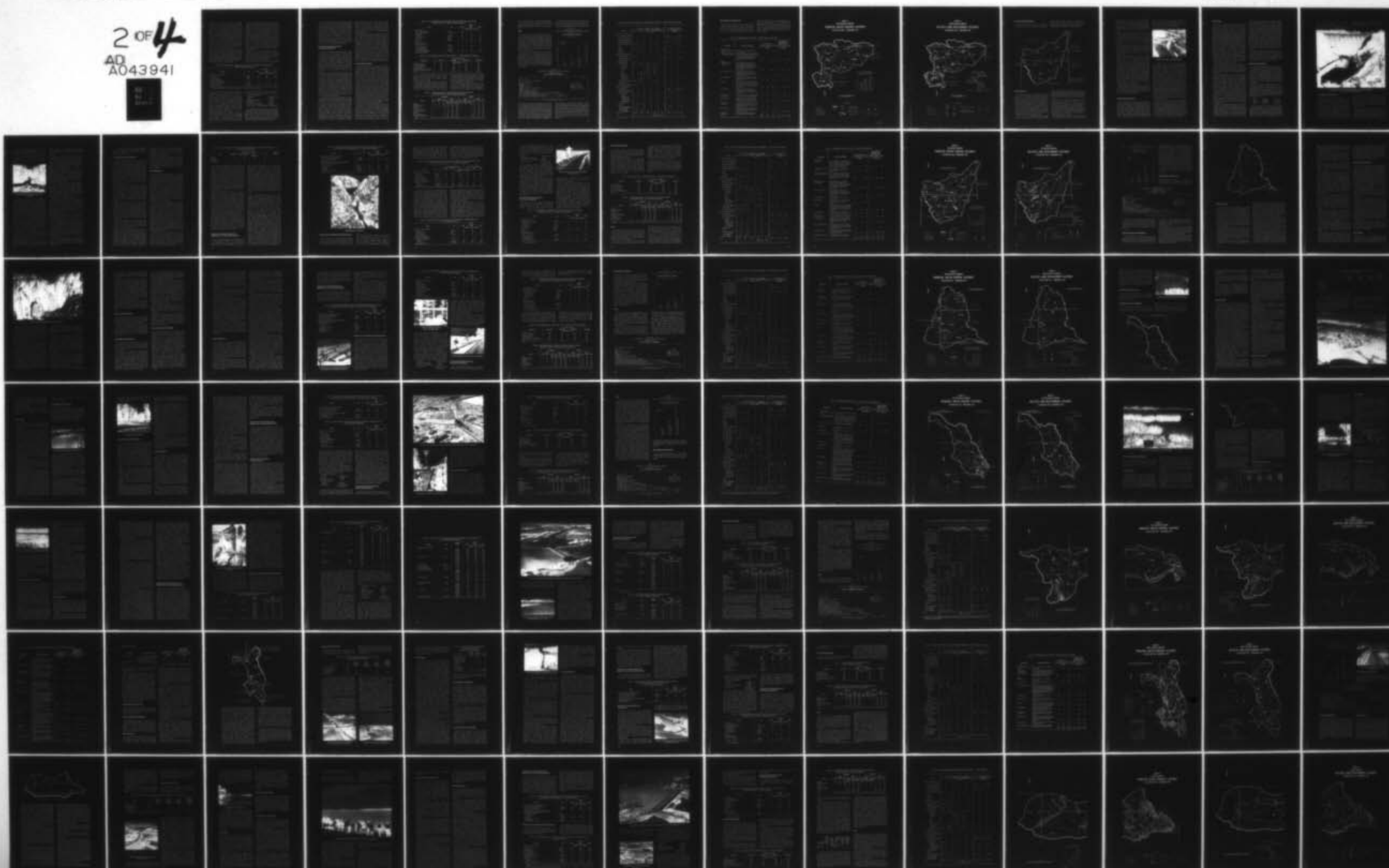

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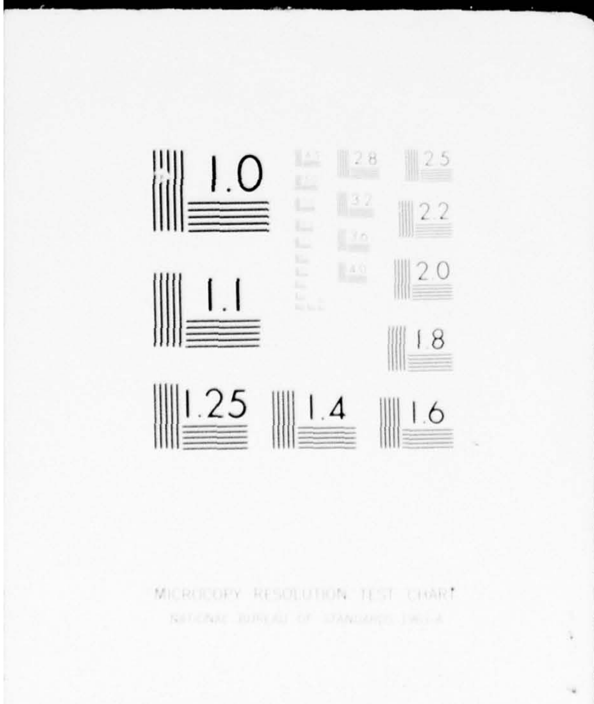
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MICROCOPY RESOLUTION TEST CHART

on either side of the river, is virtually unpopulated. Much of the area is in public ownership and is leased to ranchers for limited grazing on the range. Two conflicting and overlapping major proposals have been advocated for this area. Through sponsorship of the Bureau of Land Management, about 800,000 acres would be managed for multiple use, but with emphasis on livestock production. Management practices and development would include soil stabilization and water facilities such as stockponds and flood control ponds, and wildlife habitat would be improved insofar as practicable. Not only would livestock production be increased, but elk herds would be increased, Bighorn Sheep introduced, and deer, antelope, and bird populations increased to optimum habitat capacity.

As an alternative to the livestock intensification program, the same area could be managed for wildlife purposes. The major purpose would be to develop and maintain maximum populations of wildlife, to include elk, deer, Bighorn Sheep, grouse, wild turkey, geese, and other species. Although such management would result in considerable wildlife enhancement and propagation, it would reduce livestock to a secondary use.

In view of the need for economic enhancement of the subbasin, the wildlife enhancement that could be accomplished in connection with the domestic livestock oriented program, and the detrimental effects to the livestock economy through a basic wildlife management program, it is considered more desirable to intensify livestock agriculture in this area. Moreover, because of the generally adequate game hunting resources in this subbasin, wildlife enhancement and propagation in this area would not add significant benefits to the residents of the subbasin. Rather, such production enhancement would be to those located outside of the subbasin. Therefore, the livestock management program offers significantly more value to the local area and subregion, and was adopted with primary consideration for this subbasin objective.

Based on the several considerations outlined, a framework for future control of water and related land resources development was selected for the subbasin. The physical features of this component of the subbasin framework plan are summarized in table 31.

The surface water control features for the total framework plan through 2020 include 92 multiple-

Table 31 – WATER CONTROL AND RELATED LAND DEVELOPMENT, FRAMEWORK PLAN UPPER MISSOURI SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SURFACE WATER CONTROL				
Storage	1,000 AF	1,819	2,496	3,051
Local Protection	Miles	17	20	20
Bank Stabilization	Miles	36	108	144
LAND DEVELOPMENT				
Recreation, Fish and Wildlife	1,000 AC	15	25	38
Surface Water Irrigation[1]				
Federal Systems	1,000 AC	192	377	495
Public Land Conservation	1,000 AC	773	2,712	3,870

[1] Exclusive of 274,000 acres of presently irrigated lands to be provided supplemental water supply.

purpose reservoirs having a gross storage capacity of 2,952,000 acre-feet of storage. Of this amount, 15 reservoirs having individual capacities in excess of 25,000 acre-feet would have a collective storage capacity of 2,283,000 acre-feet, while 77 reservoirs with individual capacities of less than 25,000 acre-feet would have a collective capacity of 669,000 acre-feet. In addition to the multiple-purpose reservoirs, single-purpose reservoirs would provide a collective storage capacity of 99,000 acre-feet (through 2020). All of the single-purpose reservoirs would be for water-based recreation purposes, but not for fishing.

Of the 2,952,000 acre-feet of storage in multiple-purpose impoundments, 783 thousand acre-feet would be for sediment or other inactive uses, 1,636,000 acre-feet would be conservation storage for joint or multiple beneficial uses, and 533,000 acre-feet would be for exclusive flood control, or regulation of high flows. The joint or multiple use storage would be as follows:

Streamflow Augmentation,	
Quality	51,000 acre-feet
Irrigation	1,286,000 "
Municipal and Industrial	7,000 "
Hydroelectric	330,000 "
Recreation, Fish & Wildlife	818,000 "
Flood Control – Incidental Benefits From Regulation	

Approximately 20 miles of channel and/or levee improvements would be provided by the year 2000 for local flood protection at Sun River, Vaughn, Great Falls, Shelby, Roy, East Glacier, Grass Range, and Malta, Mont. Other in-stream control measures include 144 miles of bank protection measures located primarily on the Marias, Musselshell, Milk, and Missouri rivers.

The land development features associated with the water control elements of the subbasin framework plan include 38,000 acres of land around reservoirs which would be used primarily for recreation, fish and wildlife purposes. An integral part of the surface water systems is the development of 495,000 acres of land under public irrigation systems, including Indian projects. Also, a supplemental irrigation water supply and facilities to deliver this water to 247,000 acres of presently developed land would be provided. Land conservation practices would be applied to almost 4 million acres of federally owned land generally located in the mountain areas to the west and in the Missouri Breaks Area.

Environmental Enhancement and Non-Structural Measures

Although certain environmental enhancements would stem from plan features previously outlined, various other features have been segregated in response to the environmental plan objective. These include such items as programs for propagation of fish and wildlife, scenic area preservation and trail development, and sewage and water treatment facilities. Depending on the plan objective, the scale and intensity of some of these items will vary. Based on the same considerations previously described for the water control features, selection of developments for environmental enhancement was made.

Other than future management practices which will be dictated by legal and institutional arrangements then in force, non-structural elements considered during plan formulation included flood plain management and forestry and precipitation management programs for increasing water yields. The management of flood plains encompasses an overall acceptance of land use practices as a means for dampening the rise in future flood losses and as a means for providing open space and recreational opportunity in flood prone areas, especially near urban communities. As was pointed out in chapter 6, flood plain management was considered not only as an alternative to structural control of flood flows, but also as a complementary program thereto.

Increasing water yields through management practices dealing with forests and induced precipitation are based on forecasts of the water yields that can be anticipated in the future and the costs for producing such yields. The need for such programs will depend on when quantified water needs exceed natural supplies, ability to pay all of the costs necessary for delivery of such water, and a consideration of other alternatives that may be viable. In addition, there are legal and institutional considerations that would bear heavily on the ability to implement these types of programs. In essence, the framework plan outlines these potentials from emerging technology as one means for increasing water yields in the basin. Since the non-structural measures are generally in consonance with all plan objectives, there appear to be no conflicts — with one caution. The effects on the environment and detrimental effects that may occur will not be known until more definitive and detailed studies are made of forest and precipitation management measures.

The environmental features included in the total subbasin framework plan (2020) include sufficient water and sewage treatment facilities to meet the needs and which are in consonance with criteria outlined in preceding chapters; the preservation, development, and management of 51,000 acres of wetlands, 29,000 acres of wildlife management areas, 255 miles of scenic rivers, 8 special use recreation areas, and almost 1,200 miles of trails. The primary management programs include the preparation of 33 flood hazard reports covering 74,000 acres of flood-prone lands and forest and precipitation management practices that would increase average annual water yields by about 70,000 acre-feet and 196,000 acre-feet, respectively. Table 32 presents the features included in the environmental enhancement and non-structural element of the subbasin framework plan.

Land and Water Changes

Implementation of all of the features of the framework plan in the Upper Missouri Subbasin would result in significant changes in land use and water supply through the projection period 1965-2020. Principal changes in land use would be the conversion of non-irrigated agricultural lands to irrigated croplands; the use of crop, forest, woodland, pasture, and range lands required for construction of the various water control facilities included in the framework plan; the use of lands acquired for recreation, fish, and wildlife purposes; the conversion of lands to water through reservoir construction; and the conversion of agricultural lands for the projected needs of transportation, urban, and built-up areas. Table 33 summarizes the net land use changes for the principal categories cited. It should be noted that a category "other" is included in the table, and although the principal uses in this category are for recreation and fish and wildlife purposes, land requirements for mineral, military, and other miscellaneous uses are included therein to account for the total area. Values for the latter uses are quite small in comparison with the major uses of recreation and fish and wildlife.

Water supply studies were also made to determine the consumptive use of all waters withdrawn or diverted for the various uses envisioned from the subbasin framework plan. It was recognized, from a water accountability standpoint, that treaty requirements with Canada would be met. Accordingly, 45,000 acre-feet of water from the Milk River was treated as an export and a depletion of this amount was recognized in this stream's water supply. Increased water yields projected to accrue from

Table 32 – ENVIRONMENTAL ENHANCEMENT AND NON-STRUCTURAL MEASURES
FRAMEWORK PLAN – UPPER MISSOURI SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
ENVIRONMENTAL				
Sewage Treatment Plants[1]	Number	100	105	170
Water Supply & Treatment	1,000 AF/YR	16	51	77
Fish & Wildlife				
Wetlands	1,000 AC	10	26	51
Management Areas	1,000 AC	5	22	29
Scenic Rivers	Miles	0	135	255
Special Areas	Number	4	8	8
Trails	Miles	815	1,180	1,180
NON-STRUCTURAL				
Flood Plain Management				
Area	1,000 AC	2	42	74
Flood Hazard Reports	Number	6	11	33
Water Yield Increases				
Forest Management	1,000 AF	13	42	70
Precipitation Management	1,000 AF	20	79	196

[1]Includes existing plants.

Table 33 – NET LAND USE CHANGES, FRAMEWORK PLAN – UPPER MISSOURI SUBBASIN

Principal Use	Net Land Use Changes			
	1965-1980	1980-2000	2000-2020	1965-2020
	(Thousand Acres)			
Irrigated Cropland	+186	+210	+141	+537
Non-irrigated Cropland	- 108	- 132	- 166	- 406
Forest and Woodland	- 20	- 124	- 77	- 221
Pasture and Range	- 190	- 249	- 203	- 642
Transportation, Urban & Built-up	+ 41	+ 60	+ 85	+186
Other (Rec, F&WL, & Other Uses)	+ 52	+191	+183	+426
Water	+ 39	+ 44	+ 37	+120

forestry and precipitation management features of the subbasin framework plans would result in negative depletions to water supply, or an addition to the subbasin's total water supply.

Ground-water developments included in the subbasin framework plan are generally quite small, scattered, and confined largely to alluvial areas adjacent to streams. For the most part, withdrawals of ground water would be equivalent to stream withdrawals because of the relatively rapid recharge from streamflow. However, in order to recognize probable depletion of ground-water supplies for some small areas where recharge may not be fully effective, a ground-water depletion effect of 10 percent of the total withdrawal was assumed.

Table 34 summarizes water withdrawals for various uses and the resulting depletions of streamflow and ground water. As can be noted from the table, almost 1 million acre-feet of streamflow would be depleted by

Table 34 – WATER WITHDRAWALS, DEPLETIONS, AND OTHER CHANGES
FRAMEWORK PLAN – UPPER MISSOURI SUBBASIN

Service	Withdrawals						Depletions					
	Ground			Surface			Ground			Surface		
	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
	(Cumulative Above Current – Thousand AF/YR)											
Irrigation	0	36	60	666	1,318	1,720	0	4	6	306	628	822
M&I, Rural Domestic	8	17	29	8	34	48	2	3	4	11	24	31
Thermal Power				159	445	455				4	19	45
Livestock	6	12	20	7	13	24	1	1	2	12	24	42
Land Conservation				8	26	43				8	26	43
Wetland, Fish & Wildlife				15	61	93				15	61	93
Evaporation				44	103	136				44	103	136
Exports				0	45	45				0	45	45
Forest Management				- 13	- 42	- 70				- 13	- 42	- 70
Precipitation Management				- 20	- 79	- 196				- 20	- 79	- 196
Total	14	65	109	874	1,924	2,298	3	8	12	367	809	991

the year 2020. This value reflects a net depletion since surface yields would be increased by about 266,000 acre-feet annually by the year 2020 from forestry and precipitation management features of the framework plan.

Costs

Estimates of first cost and annual operation, maintenance, and replacement costs were made for all elements of the subbasin framework plan. As shown on figure 19, total first costs through the projection period are estimated at about $1.8 billion, with $652 million and $1.2 billion required at the bench mark years of 1980 and 2000, respectively. Annual operation, maintenance, and replacement costs are estimated to rise from $9 million in 1980 to $19 million by 2000, reaching $32 million by the year 2020.

First costs also were distributed to each functional item included in the subbasin framework plan in accordance with the criteria presented in chapter 6. The distribution of costs by functional items is shown in Figure 20. As can be noted, the largest share of the total investment would be for recreation, followed closely by irrigation and land conservation. These functions collectively account for 78 percent of the total investment requirement.

In order to have a further insight of investment requirements, studies were also made of the Federal and non-Federal responsibilities regarding cost-sharing. The cost-sharing responsibilities for the various framework plan elements were, therefore, delineated in accordance with existing policies and laws. The results of this study are summarized in table 35, and indicate that for the total framework plan initial Federal investment would approximate $787 million, of which about $603 million would be repayable by non-Federal interests over the long-term future and 3.2 million would require initial non-Federal investments. The net Federal investment would approximate $184 million. The magnitude of essentially non-Federal programs would be $984.4 million, of which $411.9 million would be available from Federal grant and assistance programs, or a non-Federal investment of $572.5 million. On the basis of current policies and laws, therefore, the cost-sharing of the total initial investments would approximate 68 percent Federal and 32 percent non-Federal and about 34 percent Federal and 66 percent non-Federal on the basis of net costs over the longer term.

FIGURE 19
ESTIMATED FIRST COSTS AND
ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENTS
FRAMEWORK PLAN
UPPER MISSOURI SUBBASIN
(cumulative above current)

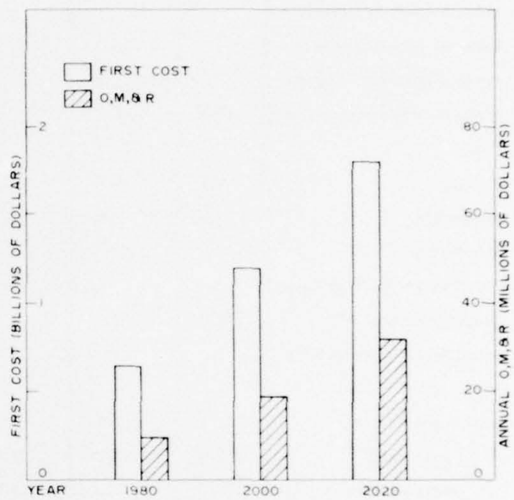

FIGURE 20
DISTRIBUTION OF COSTS BY FUNCTIONAL PURPOSES
FRAMEWORK PLAN
UPPER MISSOURI SUBBASIN

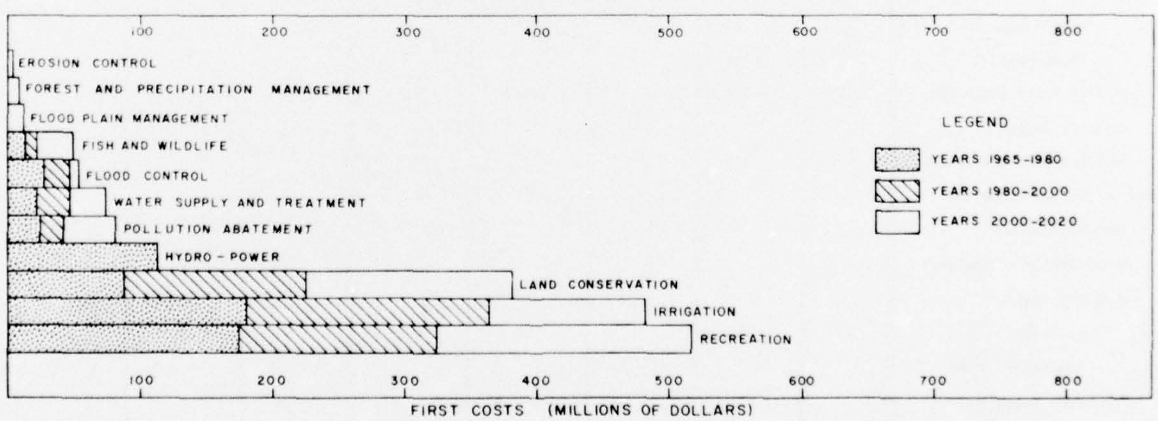

Table 35 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY – UPPER MISSOURI SUBBASIN

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						13.2		13.2
State & Local Recreation						424.9	169.8	255.1
National Recreation Area								
Private Land Conservation						374.0	187.0	187.0
Irrigation Rehabilitation	42.3	42.3		42.3				
Access						10.6		10.6
Refuges	4.8	4.8						
Hatcheries	.2	.1			.1			
Reservoirs						1.5		1.5
Water Control and Related Land								
Single Purpose F. C.	8.0	6.4			1.6			
Other Single Purpose Res.						14.9		14.9
Grade Stabilization								
Bank Stabilization	4.1	2.9			1.2			
M. P. Reservoirs	363.0	(165.4)	(197.6)	(220.6)				
Water Quality			13.4					
Irrigation			85.3	85.3				
M & I			11.2	11.2				
Power		88.0	21.6	109.6				
Recreation		29.0	33.1	14.5				
Fish & Wildlife			33.0					
Flood Control		48.4						
Surface Water Irrigation	340.1	340.1		340.1				
Group Drainage								
Public Land Conservation	9.6	9.6						
Environ. and Non-Structural								
Sewage Treatment						66.0	19.8	46.2
Water Supply & Treatment						63.9	31.9	32.0
Fish and Wildlife								
Wetlands	5.7	5.4		.3				
Management Areas						6.5	3.4	3.1
Fish Hatcheries								
Fish Impoundments								
Scenic Rivers	2.7	2.7						
Trails	.5	.5						
Flood Plain Management	.6	.6				8.9		8.9
Forest Management	.9	.9						
Precip. Management	7.5	7.5						
Totals	790.0	589.2	197.6	603.0	3.2	984.4	411.9	572.5

1965-2020 Total: 1,774.4

Short-Range Framework Plan

The preceding descriptions and discussions have covered the entire subbasin as well as plan features covering the entire projection period through 2020 and have been of a general nature. Recognizing that projections of the future have diminishing accuracy and adequacy into the long term, the short-range elements of the total framework plan (to year 1980) have been disaggregated from the preceding material. Table 36 presents a concise description, together with pertinent data, on the subbasin framework plan at the 1980 level. Figures 21 and 22 show the principal elements of the 1980 framework.

Table 36 – FRAMEWORK PLAN FOR 1980 – UPPER MISSOURI SUBBASIN

Plan Feature	Description and Purpose	Initial First Costs Federal	Initial First Costs Non-Fed	Initial First Costs Total	Annual Operation, Maintenance and Replacement Costs Federal	Annual OM&R Non-Fed	Annual OM&R Total
		($ Million)			($ Thousand)		
Storage Reservoirs							
Single-purpose Impoundments	Recreation reservoirs with 20,000 acre-feet of storage.	0	3.0	3.0	0	10	10
Multi-purpose Impoundments, Major and Minor	Seven impoundments having 1.632 million acre-feet of storage and 23 minor reservoirs with a capacity of 167,000 acre-feet for water quality, irrigation, M&I, power, recreation, fish & wildlife, and flood control.	223.0	0	223.0	395	715	1,110
Irrigation							
New Systems and Rehabilitation	Provide 192,000 acres of irrigation subbasin-wide, consolidate 657 miles of ditches, line 319 miles of ditches, and drain 24,000 acres providing the equivalent of 47,000 new irrigated acres (subbasin-wide).	146.0	0	146.0	0	866	866
Local Flood Protection	Channel and levee improvements involving 17 miles for protection at Sun River, Vaughn, Great Falls, Shelby, Roy, and Malta, Montana.	5.9	1.5	7.4	0	37	37
Bank Stabilization	Bank protection on the Marias, Musselshell, Milk, and Missouri rivers covering 36 miles.	0.7	0.3	1.0	0	10	10
Recreation	The development of 246,000 acres by the State, local, and private sector; providing 16 new access sites to existing water, and 815 miles of trails - generally throughout the subbasin.	57.4	88.7	146.1	0	1,786	1,786
Fish and Wildlife	5,000 acres for game management, 10,000 acres for wetlands, 5,000 acres for a refuge addition, and one fish hatchery modification.	2.5	0.5	3.0	32	26	58
Water Supply and Treatment	Treatment facilities to serve 68,000 people and development of individual supplies.	8.9	8.9	17.8	0	370	370
Sewage Treatment	Enlargement of 66 secondary facilities, additions to 14 secondary facilities, and constructing 20 new secondary facilities.	5.1	11.9	17.0	0	2,192	2,192
Water Yield Management	Forestry practices to yield 13,000 acre-feet of additional water and precipitation management to produce 20,000 acre-feet of additional water.	.5	0	.5	1	0	1
Land Conservation	Land treatment measures for 4,587,000 acres of private land and 773,000 acres of federally owned land.	43.8	42.0	85.8	11	2,600	2,611
Flood Plain Management	Preparation of 6 flood hazard reports covering 2,000 acres of flood plains.	0.1	1.1	1.2	1	5	6
Total		493.9	157.9	651.8	440	8,617	9,057

FIGURE 21

UPPER MISSOURI SUBBASIN

PRINCIPAL WATER CONTROL FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

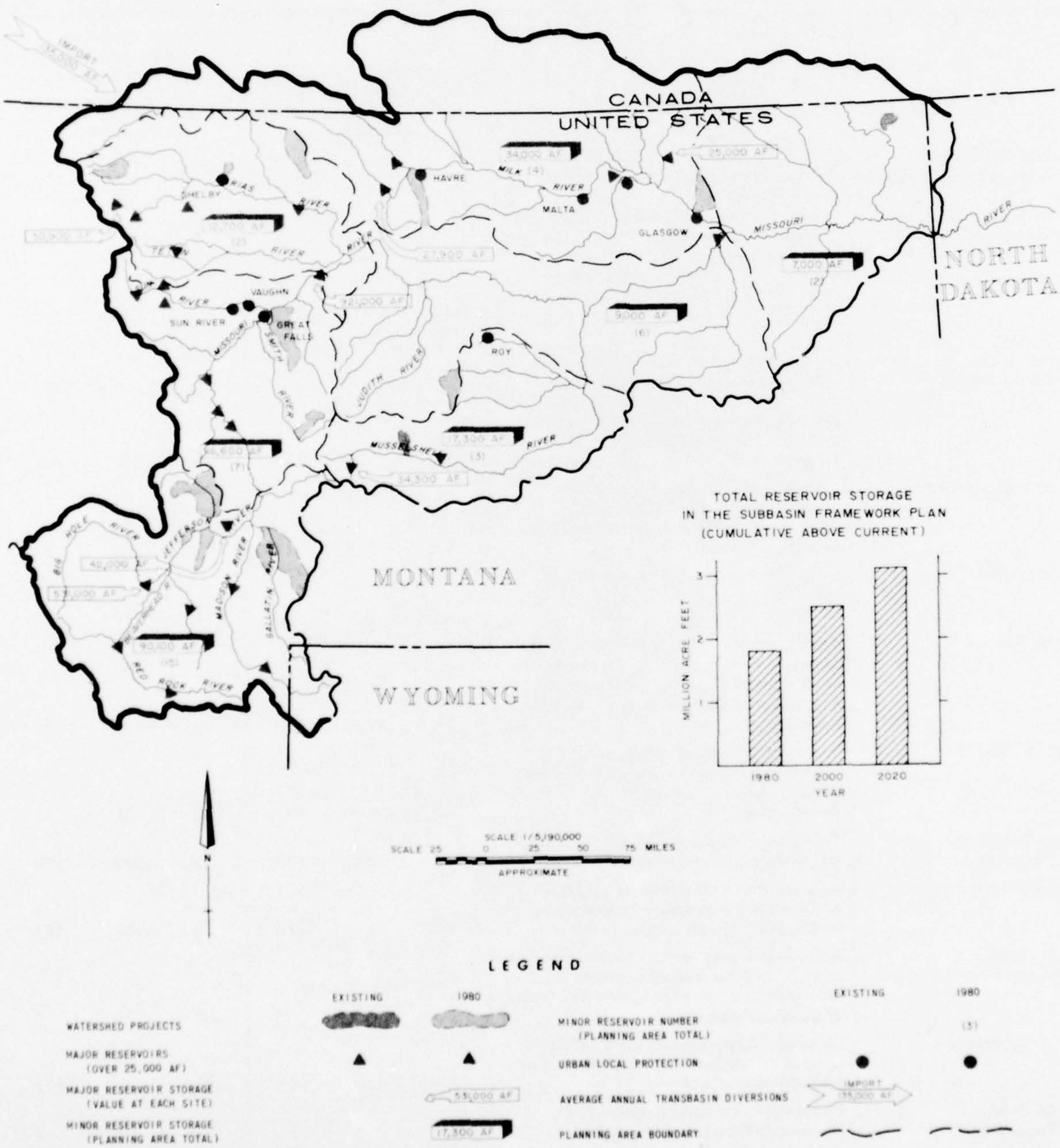

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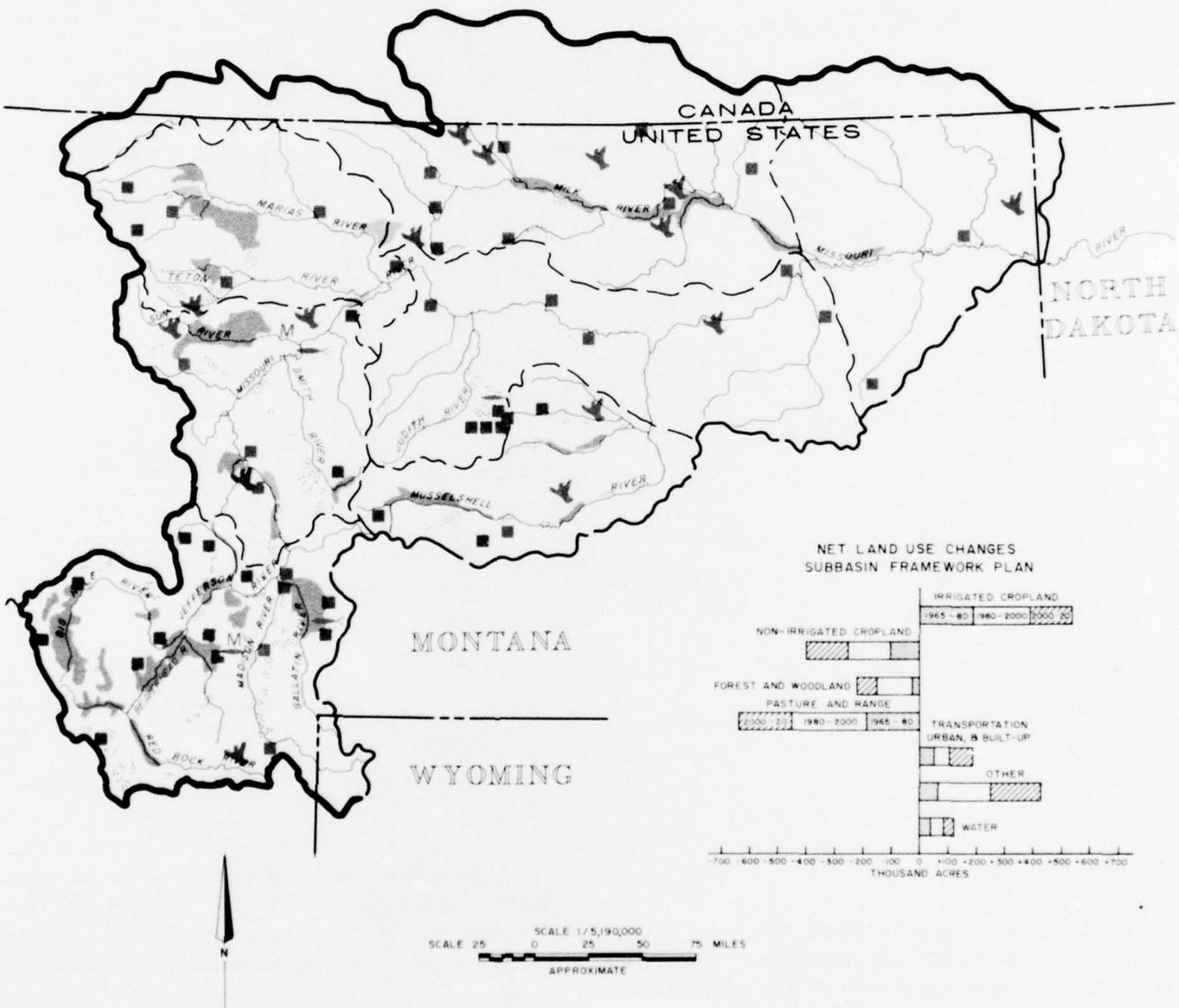
FIGURE 22

UPPER MISSOURI SUBBASIN

RELATED LAND DEVELOPMENT FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

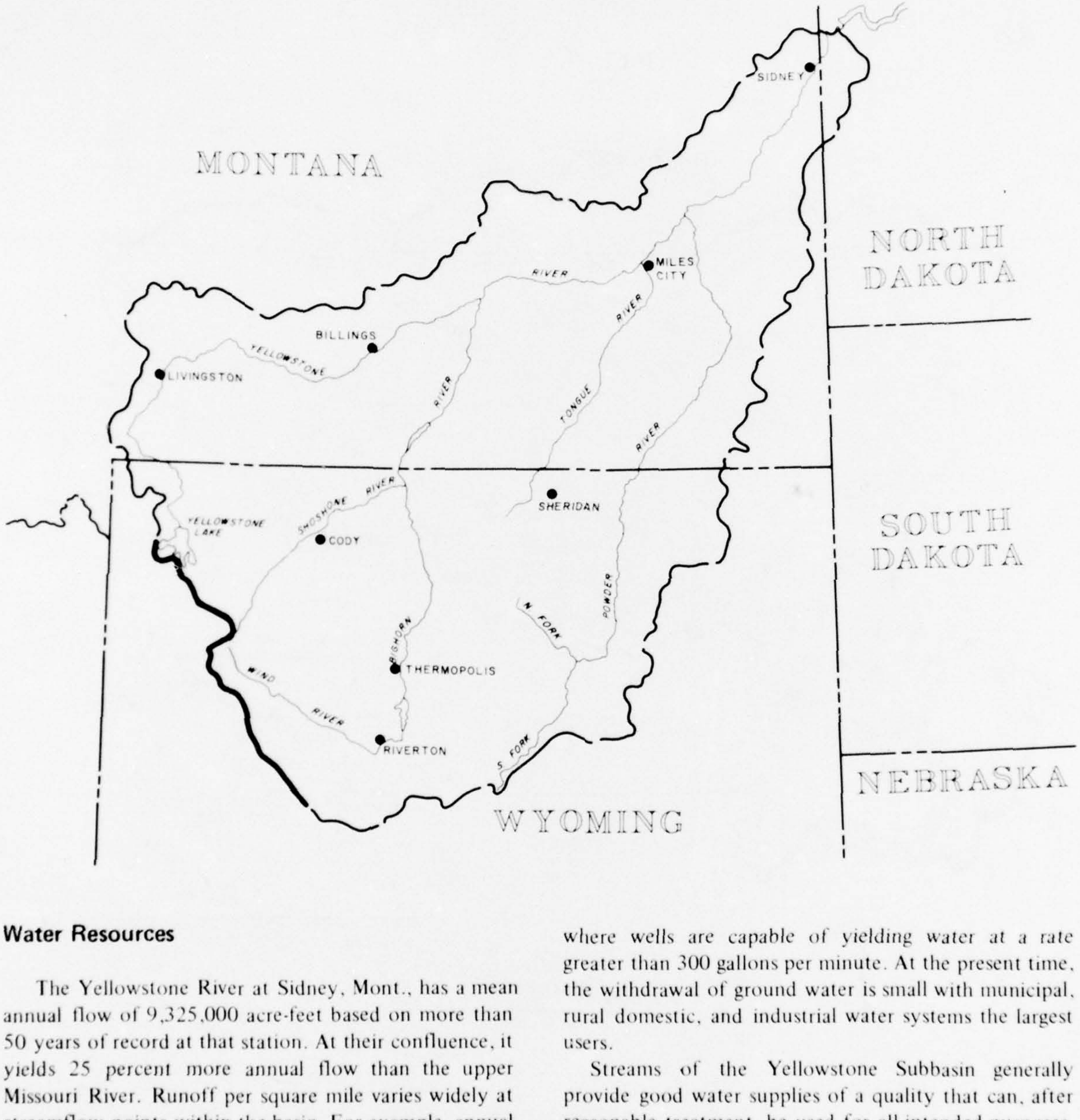


LEGEND

	EXISTING	1980		EXISTING	1980
IRRIGATION			MODIFICATION OF EXISTING PROJECTS		M
WATER BASED RECREATION	■	■	PLANNING AREA BOUNDARY		
FISH HATCHERIES			LAND CONSERVATION - SUBBASIN TOTAL (AREAL COVERAGE NOT SHOWN ON MAP)	24.2 MIL. AC	5.4 MIL. AC
WILDLIFE MANAGEMENT AREAS					

YELLOWSTONE SUBBASIN

The subbasin includes the drainage of the Yellowstone River and its tributaries in northern Wyoming, southern Montana, and a portion of western North Dakota. It has a drainage area of about 70,600 square miles. Two-thirds of the area is privately owned agricultural land with the remainder in Federal ownership.



Water Resources

The Yellowstone River at Sidney, Mont., has a mean annual flow of 9,325,000 acre-feet based on more than 50 years of record at that station. At their confluence, it yields 25 percent more annual flow than the upper Missouri River. Runoff per square mile varies widely at streamflow points within the basin. For example, annual runoff of the Powder River near Locate, Mont., is 31 acre-feet per square mile compared with 115 acre-feet per square mile for the Bighorn River at St. Xavier, Mont., 357 acre-feet per square mile for the Clarks Fork at Edgar, Mont., and 728 acre-feet per square mile for the Yellowstone River near Livingston, Mont.

There are nearly 15,000,000 acre-feet of ground water in storage in areas of the Yellowstone Subbasin, where wells are capable of yielding water at a rate greater than 300 gallons per minute. At the present time, the withdrawal of ground water is small with municipal, rural domestic, and industrial water systems the largest users.

Streams of the Yellowstone Subbasin generally provide good water supplies of a quality that can, after reasonable treatment, be used for all intended purposes. The relatively good quality results from the ability of the streams to assimilate the discharged wastes which are small in comparison with the stream flows. This does not mean that there are no quality problems. Billings, Mont., the largest city in the subbasin, needs to augment its present waste treatment facilities.

In 1965 there were 65 central water systems that served 194,000 people, which is 72 percent of the 1960

population. Of this number, 57 communities have sewerage systems, with 38 secondary and 18 primary waste treatment plants. With the many connected industries the gross waste loading is 240,000 population equivalents which the existing treatment plants reduce to 89,000 P.E., most of which is discharged to the streams.

The petroleum industry does a better job of waste treatment than do the food processors. Food and meat processing plants and the sugar plants need to provide more effective treatment of the wastes before discharging them to the receiving streams. Large quantities of inorganic and some organic wastes are discharged untreated.

The six thermal-electric power plants in the subbasin use flow-through cooling systems and divert about 96,600 acre-feet of water for this purpose. Fortunately, the receiving streams are of adequate size to accept the heat from the condenser cooling water with no adverse thermal effects.

There are adverse effects on the fishery from silt originating naturally and in the return flows from irrigation. Much of the silt originates from natural phenomena, but there are problems also in many areas where irrigation is practiced. Silt appears most critical in the Clarks Fork River and the Yellowstone River downstream from their confluence. Return flows from 1,188,000 acres of irrigated land carry agricultural chemicals and other dissolved solids back to the streams.

Natural hot springs near Cody and Thermopolis, Wyo., contribure hot mineralized flows to the Big Horn River. Thermal power generation near Acme, Wyo., causes heat pollution in the Tongue River. About 37 miles of the Yellowstone River in Park and Yellowstone Counties, Mont., are polluted by municipal and industrial wastes to such an extent that the stream fishery has been seriously degraded.

The dissolved solids concentration in the streamflow leaving the subbasin is about 430 mg/l. This concentration results from salts in the natural runoff plus those in the return flow from 1.2 million acres of irrigation and in the municipal and industrial effluents.

Flood and Erosion Control

Twelve major projects in the subbasin provide varying degrees of flood control and flood damage reduction to approximately 142,000 acres of land, including 15 urban communities. Of these projects, five provide local flood protection generally through channel improvements and levees while the remainder are reservoir projects. Two of the reservoir projects have exclusive flood control storage and the remainder provide some incidental flood control through reservoir operation. These existing projects reduce annual flood damages by about 20 percent. Current flood damages, with the projects in place, are estimated at $2,318,000 annually, covering flood plain areas approximately 700,000 acres.

Erosion Can Be Widespread and Destructive

Streambank erosion is most significant along the lower reaches of the Yellowstone, Clarks Fork, Big Horn, Tongue, and Powder rivers with about 2,450 bank-miles, or slightly over one percent of the existing channel banks, receiving serious erosion. Average annual losses due to streambank erosion are estimated to be $470,000. With the exception of extensive grade and bank stabilization improvements on Five Mile and Muddy creeks above Boysen Reservoir, there are no major existing improvements for the control of streambank erosion or for gully erosion control. Limited local bank protection projects have been installed at more than 20 locations, primarily at bridges and at some urban communities. These projects, which required relatively high initial costs, have limited useful lives, and maintenance is rather difficult and expensive because of ice jam conditions and the unpredictable nature of channel meander. Although a few major reservoir projects in the subbasin exercise a certain degree of stream regulation, the net effect of such control on bank erosion is uncertain.

Gully erosion problems, as contrasted to streambank erosion, occur at locations having a wide range of topographic and physical land characteristics. There are a number of localized areas that have significant gully erosion problems that will require project-type action.

It is estimated that nearly 800 acres are lost each year to voiding and to depreciation by gullies of the size and nature to require consideration of project-type action to treat. Under current conditions, average annual losses due to gully erosion are estimated to be $281,000.

Water Supply

Agriculture constitutes the largest water using industry in the subbasin. Agricultural development was begun by cattle ranchers and by homesteaders who attempted dry farming. Development of irrigated farming in the subbasin dates back to the 1880's and 1890's when some of the first diversions were made from streams for the raising of crops. Large diversions by private groups began about 1883. The passage of the Carey Act in 1894 added impetus to the expansion of irrigation. There are currently 3,374,000 acres of cropland in the subbasin of which 1,031,000 acres are irrigated and 2,343,000 acres are dry farmed. About 157,000 acres of pasture and range are also irrigated. Most of the irrigation is accomplished through institutional arrangements, but there are an increasing number of operators who provide their own systems, pumping from either streams or ground water. Federally constructed systems account for 312,000 acres, or 26 percent of the total. Some of this land is furnished only a supplemental water supply. The balance of the total was developed by the States, corporations, cooperative ventures, irrigation districts, or other forms of promotional or owner-oriented organizations.

An analysis indicates that about 1,423,000 acres could be served by existing systems. This is about 20 percent greater than the area normally irrigated, and points to the fact that improvement of the existing systems maybe an effective way of increasing output or efficiency.

The principal deficiencies noted are water shortage, and/or land development in excess of water supply, inadequate rotations including those for nonirrigated crops, seasonal weather problems, and excess water in the soil. The potential of this land can be enhanced, however, by rehabilitation of the systems. Some could be restored to regular irrigation service if the water supply and disposal systems were improved. In many cases, the only solution to late-season water shortages is storage in the headwaters of the smaller tributaries.

Livestock water supply use approximates 20,000 acre-feet per year. Approximately 58 percent of the demand is met from surface-water sources and 42 percent from ground water. Problems associated with livestock watering are the deterioration of streambank vegetation and erosion which occur in heavily used watering areas.

Of the 77 municipalities and villages in the subbasin in 1965, 65 of them, having an aggregate population of 194,000 persons, were served by public water supply systems. Rural people either develop their own individual water systems or are served by the extension of central water systems. Gross water withdrawals for these purposes approximated 33,000 acre-feet in 1965.

Many industries obtain their water through municipal water supply systems, but the larger water consuming industries generally develop their own supply. Twenty-six industries in the Yellowstone Subbasin reported individual water supplies in a 1965 survey. Present uses of water for indistrial purposes are confined principally to thermal-electric power production and the processing of agricultural and mineral products. In general, industrial users divert substantial quantities of water and return it to the stream in the same general locality with a relatively small consumptive use. Thermal powerplants are using about 97,000 acre-feet annually but less than 1 percent of this is consumed. The petroleum and mineral industries divert about 76,000 acre-feet, the sugar beet refining industry diverts about 11,000 acre-feet, and all other industries combined divert an additional 73,000 acre-feet.

The current demand is satisfied 94 percent by surface water and 6 percent by ground water. One water system is presently inadequate because of the quantity of available water, but all systems have adequately treated water supply. However, an improved quality source would be desirable for four central water systems.

Electric Power Generation

In recent years, the demand for power in the subbasin has exceeded the installed capacity and energy production. In 1965, about one-third of the energy used in the subbasin was imported. Although this area is usually associated with hydroelectric power, only about 20 percent of the 188 megawatts installed in the subbasin in 1965 was of this type. The balance of the capacity was in thermal-electric plants, burning coal, lignite, oil, and gas. However, most of the imported energy came from hydro-plants.

The balance between thermal and hydro for the existing situation is altered by completion of two plants, one hydro (Yellowtail, 250,000 kilowatts) and one steam (Montana Power Company's J. E. Corette, 180,000 kilowatts). Yellowtail Power Plant was placed in service in 1967, and the Corette plant went on the line in late 1968. At the present time, installed capacities in the subbasin are:

Hydro	288,000 kw	47 percent
Thermal	330,000 kw	53 percent
Total	618,200 kw	100 percent

The major suppliers of electric energy in the subbasin all have transmission systems connected to plants in adjacent basins, so the question of installed capacity within the basin is somewhat academic. In a short time, however, it is expected that the subbasin will become an exporter of energy due to the potential of the coal

reserves. These same transmission systems would then move energy out of the basin.

There appear to be no significant problems connected with the operation of electric power plants in the subbasin or the supplying of adequate energy for use in the subbasin, and none are foreseen with the shift from importing to exporting status.

In Addition To Other Purposes, Yellowtail Dam and Reservoir Provide For Hydroelectric Power Production

Fish, Wildlife, and Recreation

Wildlife makes use of nearly 43 million acres, or 94 percent of the subbasin area. Only 53,000 acres of land are used exclusively for fish and wildlife. However, virtually all of the 323,000 acres of water in the subbasin are valuable in some way to fish and wildlife.

The opportunity for cold-water fishing, mostly for trout, is abundant, and a substantial part is of exceptionally high quality. One hundred thirty-four miles are *trout streams of national importance, or Class 1. Class 2* streams, of statewide importance, amount to 410 miles. Streams of local importance account for the remainder of the classified miles. Somewhat less than 200 stream miles are polluted, and have no value as a fishery. In addition, there are almost 2,300 miles of unclassified streams in Yellowstone Park that provide abundant fishing. There is a total of 205,000 acres of lakes, reservoirs, and ponds in the subbasin including 91,000 acres of lakes inside Yellowstone Park which provide fishing opportunity.

The Yellowstone River has been recognized for its recreational significance and potential by proclamation *of the Montana State Game and Fish Department.* By this proclamation, the river was designated as a free-flowing recreation waterway. The Montana Senate and House of Representatives introduced a joint resolution

of public policy regarding maintenance of the unique natural features of the Yellowstone River.

Current use of the subbasin fishery does not approach capacity. Streams are utilized at about 25 percent of capacity, reservoirs and lowland lakes at 16 percent, and mountain lakes at 6 percent. The low degree of use of mountain lakes is principally attributable to the limited access.

High Quality Trout Fishing Is Typical of the Subbasin

Despite the relative excellence of the fishing waters of the subbasin, habitat problems exist. Serious sedimentation of streams is common, resulting both from natural soil characteristics and improper land use. Dewatering of streams has been and will continue to be a serious problem. Wastes from feedlots and oil and gas operations, extensive pesticide use, and municipal and industrial wastes are also recognized problems.

The subbasin is widely known and of national importance for its outstanding big game hunting. Deer, antelope, and elk are the most important species, with bear, moose, mountain goat, and Bighorn Sheep also found, but in lesser abundance. There is a wide variety of small animals and game birds. For both big and small game, the subbasin provides opportunities difficult to match almost anywhere in the Nation. Waterfowl resources are limited, however, because of the lack of natural wetlands and developed habitat areas.

At the present time, the resources are well able, in gross numbers, to meet the demand. Analysis of the supply-demand-relationship discloses, however, that big game is on the verge of falling short of needs and waterfowl already have fallen short.

Siltation is considered to be the greatest single depreciating influence on the sport fishery of the Yellowstone Subbasin. It is primarily related to natural phenomena, but also in part to poor irrigation and grazing practices on the erodible soils of the area. The Yellowstone River, as an example, is seriously affected below Laurel, Mont., by silt entering from the Clarks Fork River.

Pollution is also a problem in the subbasin, coming from agricultural, industrial, and domestic sources. Pollution often affects the food chain of immature stages of fish before it is apparent in the adult, and its control is usually difficult. Dewatering is a common occurrence, with resultant harm to fish through increased water temperatures, greater concentration of pollutants, and reduced living space.

Since most of the ducks in Yellowstone Subbasin are migratory, the local problems reflect larger regional and national difficulties. Loss of nesting habitat and drought are the two principal causes of low waterfowl numbers. Local management and development programs can do no more than attempt to maintain populations and sustain desirable seasons and bag limits.

The total land area devoted to outdoor recreation, other than hunting and fishing, in the subbasin is 19,689,000 acres. Of that amount, the land dedicated primarily to recreational use is 1,408,000 acres, and the area intensively developed for recreation amounts to 14,000 acres. Large federally administered areas, including Yellowstone National Park, eight national forests and grasslands, and the public domain, account for 96 percent of the recreational land area.

In the Yellowstone Subbasin there were seven type I recreational areas inventoried, 139 of the Type II, and 65 Type III. There are an estimated 65 State and local parks providing facilities for both land- and water-oriented recreation, and an uncounted number of privately owned developments. The subbasin contains 3.7 million acres of wilderness-type area, most of it situated within Yellowstone National Park and the several national forests.

There are 10 major Federal reservoirs, eight in Wyoming and two in Montana, with 123,000 land acres and 51,000 water surface acres; only three of these reservoirs are appreciably developed for recreation.

A newly created area expected to be an outstanding attraction is the Bighorn Canyon National Recreation area, featuring Yellowtail Dam and Reservoir. The city of Billings provides an extensive, well balanced recreational system within its corporate limits. The private sector has always taken an important part in recreation in the area. Its principal business is that of furnishing lodging and service facilities, swimming pools, and concessions.

Tourists dominate the recreation scene, with 74 percent of the total demand listed as non-resident, and most of the use occurring during the 3 summer months. Billings, Mont., represents the only area of concentrated resident demand.

An emerging problem is the highly imbalanced pressure on Yellowstone National Park, with a need for additional or substitute opportunities that will satisfy park-oriented demands.

Land Conservation and Drainage

Currently, 3.4 million acres of the privately owned lands in the subbasin are used for crop production, 24.3 million acres are used for pasture and range, 1.6 million acres are in forest and woodlands, 91 thousand acres are in other agricultural uses, and 259 thousand acres are in non-agricultural uses. About one million acres of cropland and 157 thousand acres of pasture and range are irrigated annually. An additional 235 thousand acres of land receive intermittent applications of irrigation water. About 13.8 million acres of Federal land is used for agricultural purposes, 9.4 million are grazed, and 4.5 million produce forest products. An additional 1.4 million acres of Federal land are used for non-agricultural purposes.

Of the 3.4 million acres used for cropland, 3.1 million acres, or 91 percent, are suitable for sustained cultivation with proper management and conservation measures. The remaining 271 thousand acres of cropland are not suitable for continuous cultivation without sustaining damage to the soil resources. Conversely, about 2.3 million acres of pasture and range are physically suitable and can be used for sustained crop production with proper management and conservation measures.

Wind and water erosion seriously affect lands in the subbasin. Through their own efforts, and with Federal technical assistance and cost-sharing available to them, the owners and operators have installed adequate conservation treatment and management on 11.4 million acres of the private agricultural lands. Management-type practices on 12.8 million acres and mechanical or vegetative-type practices on 5.4 million acres are needed to provide adequate levels of conservation treatment and management.

On federally owned lands, 71 percent, or 10.8 million acres are currently adequately treated and managed. The remaining 4.4 million acres in the subbasin need improved conservation treatment and management for sustained use without deterioration.

There are approximately 441 thousand acres of agricultural land in the subbasin subject to excess water problems. This is exclusive of the 170 thousand acres of land with an excess water problem caused by irrigation water that is included in current irrigation systems. Currently, 109 thousand acres of cropland have been provided with adequate drainage. Of the remaining 332 thousand acres subject to excess water, 37 thousand acres are considered potentially suitable and feasible to drain. None of this area is currently cultivated. An additional 32 thousand acres of pasture and range and five thousand acres of forest and woodland are subject to problems of excess water and are suitable for conversion to cultivated uses. There are no group drainage needs in this subbasin.

About 288 thousand acres, or 65 percent, of the land with excess water problems are considered infeasible to drain. Of this total, three hundred acres are currently used for cropland and should be converted to non-crop uses. This and the remainder should be used for grazing and woodlands and managed to utilize its natural value as wildlife habitat.

Planning Objectives

The economy of the subbasin is raw material oriented with major employment in agriculture, mineral, and forest industries. As is the case with the Upper Missouri, the Yellowstone Subbasin is sparsely populated with a density in 1960 of less than four persons per square mile. Billings, Mont., with a population of 65,600 in 1960 is the only large community in the subbasin and has nearly 25 percent of the subbasin's population. Because of the low population density, the relatively small labor force, and generally low consumer product demands, general manufacturing has and will continue to have a competitive disadvantage with other more populated sections of the region and the Nation. Some advantages do exist, however, in the processing of agricultural commodities and the development and processing of fuels in the subbasin.

Over one-half of the total coal reserves in the Nation are located in southeastern Montana, northeastern Wyoming, and the western portion of the Dakotas. This represents a massive raw material base for the potential production of thermal-electric power, synthetic liquid and gaseous fuels, and coal chemicals. As petroleum reserves are depleted, synthetic petroleum products could be developed from the coal to meet regional as well as national energy demands. Large amounts of coal and water are required for the basic process. In order to produce 100,000 barrels per day (bpd) of gasoline, 30,000 tons of coal and 28 million gallons of water per day (31,000 acre-feet per year) would be required. For a plant life of 40 years, some 360 million tons of coal would be required. The capital investments required are also very high, being $300 million for a plant producing 100,000 bpd of gasoline.

The potential for industrial development of the coal reserves of this area are considered very good with several land and water options in force, and it is anticipated that such development will probably take place in the near future. As an indication of the natural fuel resource available to support such development, table 37 presents estimates of remaining coal reserves and the amount of known strippable reserves.

Table 37 – REMAINING COAL RESERVES AND KNOWN STRIPPABLE RESERVES PRINCIPALLY IN YELLOWSTONE SUBBASIN

State	Remaining Coal Reserves				Strippable Reserves
	Bituminous	Sub-bituminous	Lignite	Total	
			(Billion Tons)		
Montana	2	132	88	222	14
Wyoming	13	108	---	121	13
North Dakota	---	---	351	351	4
South Dakota	---	---	2	2	---

The Yellowstone Subbasin is one of the most important areas for recreation and tourism. Of the total travel and recreation demands, about 75 percent originates from outside the subbasin. The greatest proportion of tourists, about 90 percent, visit the area during the June through August period. The recreation industry, therefore, suffers from seasonality which tends to dampen its importance locally as a major economic force. In view of the extensive scenic attractions, the considerable fishing, hunting, and other recreational attributes of the area, an opportunity does exist for the recreation industry to become a more vital part of the overall economy. This will require a strengthening of the basic economy of the subbasin and an extension of the recreation season.

The principal planning objectives for the Yellowstone Subbasin are, therefore, to intensify agricultural production and processing of agricultural products, development for the industrial processing of coal, and expansion of the recreation and tourist industry. Water and land resource development has a vital role to play if these objectives are to be attained. While it is obvious that certain of the major goals are developmentally oriented and would involve a greater consumption of water, environmental preservation and enhancement considerations are also major goals and must be integrated into the plan if full advantage for future social and economic gains is to be realized in this subbasin.

Because of the relatively underdeveloped character of the subbasin's economy and its tremendous environmental attributes, formulation of a subbasin framework plan required a relative close scrutiny of alternatives. Accordingly, as was the case in the Upper Missouri, plans maximizing developmental as well as environmental objectives were formulated. From these, a subbasin framework plan was selected which more nearly meets all significant social and economic objectives.

Specified Non-Federal Programs and Modifications of Existing Developments

For the same basic reasons previously described for the Upper Missouri Subbasin, it is anticipated that private irrigation from ground-water sources, the development of recreation by the State, local, and private sectors, and the installation of land conservation practices will take place at varying rates in the future. Development of limited ground-water irrigation for 29,000 acres by the private sector has been projected on the basis of available water supply, land suitability, ability and willingness of individuals to assume the costs of such development, and historic or emerging trends for such development. Recreational development by the State, local, and private sectors included in the total framework plan includes lands and facilities to meet projected future needs. The extent and magnitude of such development, involving 707,000 acres of land, have not been constrained by any factors. Continuation of private land conservation programs reflects the projection of historic trends for implementation of these measures.

Other opportunities for increasing the economic efficiency and the flow of goods and services include modification of existing irrigation systems for conserving water, reducing operation and maintenance costs, and increasing agricultural production (efficiency gain); the modification of two reservoirs to increase their storage capacity; providing fishing and recreation access to existing reservoirs or other bodies of water; and expansion of a fish hatchery. Improvement of existing irrigation systems could result in efficiency gains equivalent to 68,000 acres of new irrigation, and significant savings in operation and maintenance costs. The capacity of Buffalo Bill Reservoir on the Shoshone River could be increased 181,000 acre-feet by raising the crest and modifying the outlet works and spillway. The additional capacity would be regulated primarily for irrigation use, but would also have added values for fish, wildlife, recreation, and power operation. Similarly, the Tongue River Reservoir could be provided an additional 206,000 acre-feet of capacity for flood control and irrigation purposes. Additional use of existing quality areas for fishing and recreation could be provided with improved access. Because of the vast opportunities for such uses, the access would be minimal, involving about 1,800 acres of land. One fish hatchery should also be expanded to improve its productivity. Table 38 summarizes the physical features of the specified non-Federal programs and modifications of existing developments included as a part of the total framework plan.

Table 38 – SPECIFIED NON-FEDERAL PROGRAMS AND MODIFICATIONS OF EXISTING DEVELOPMENTS, FRAMEWORK PLAN – YELLOWSTONE SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SPECIFIED NON-FEDERAL PROGRAMS				
Private Ground-water Irrigation	1,000 AC	7	22	29
State, Local, and Private Recreation	1,000 AC	131	393	707
Private Land Conservation	1,000 AC	3,232	7,455	12,165
MODIFICATIONS OF EXISTING DEVELOPMENTS				
Irrigation System Improvements				
Ditch Consolidation	Miles	125	492	734
Ditch Lining	Miles	166	686	1,040
Drainage	1,000 AC	60	120	170
Reservoirs	1,000 AF	206	387	387
Fishing & Recreation Access	Number	20	60	150
Fish Hatcheries	Number	0	1	1

Buffalo Bill Dam and Reservoir

Water Control and Related Land Development

As was the case in the Upper Missouri Subbasin, water and related land development plans were formulated in response to the planning objectives. The key to a developmental program for the subbasin which stresses national-regional economic objectives is an extensive system of multiple-purpose reservoirs. This system would consist of 82 multiple-purpose reservoirs, of which 12 would have individual storage capacities of more than 25,000 acre-feet and the remaining 70 reservoirs would have individual capacities less than that

amount. For a plan stressing the environmental objective, the total storage capacity of the cited system would be reduced from just over 6.5 million acre-feet to about 640,000 acre-feet. All other plan features of local flood protection, bank erosion control, drainage, land development programs for fish, wildlife, recreation, and land conservation on federally owned lands are generally compatible with all planning objectives. In view of the natural, scenic, and other environmental attributes of the area, it is inevitable that the principal conflicts would be between reservoir systems and environmental preservation concepts. Table 39 presents the physical composition of water and related land development features for plans stressing the objectives cited.

Table 39 – WATER CONTROL AND RELATED LAND DEVELOPMENT NATIONAL-REGIONAL AND ENVIRONMENTAL OBJECTIVES – YELLOWSTONE SUBBASIN

Feature	Unit	National-Regional Objective			Environmental Objective		
		1980	2000	2020	1980	2000	2020
		(Cumulative Above Current)					
SURFACE WATER CONTROL							
Storage	1,000 AF	289	659	6,507	190	434	642
Local Protection	Miles	14	20	20	14	20	20
Bank Stabilization	Miles	28	83	111	28	83	111
Grade Stabilization	Structure	14	84	194	14	84	194
LAND DEVELOPMENT							
Recreation, Fish & Wildlife	1,000 AC	34	70	93	30	64	84
Surface-water Irrigation							
Federal	1,000 AC	41	87	139	23	31	31
Non-Federal	1,000 AC	142	344	469	46	47	47
Public Land Conservation	1,000 AC	778	2,723	3,891	778	2,723	3,891

As stated, the principal areas of conflict between the features shown in table 39 are limited to magnitude of reservoir storage and environmental considerations. The environmental considerations are primarily items related to scenic values and preservation of streams in their existing state. In order to meet some portion of the economic objectives relative to agricultural and industrial economic development, reservoir development is necessary. Analyses of the reservoirs outlined for the economic objectives indicate that a significant portion of the economic objectives could still be met with the elimination of four major reservoirs with individual storage capacities greater than 25,000 acre-feet, and one small reservoir (under 25,000 acre-feet capacity). This reduced the total storage from about 6.5 million acre-feet to 2.1 million acre-feet. The goods and services foregone by the elimination of these reservoirs would be primarily hydro-electric generation, flood control, and incidental benefits from streamflow regulation. It is considered that such action would provide the best plan for achieving the objectives for the area. Table 40 summarizes the physical features of this component of the subbasin framework plan.

Surface water control features for the subbasin framework plan include 78 reservoirs, of which 77 would be multiple-purpose and one single-purpose. The single-purpose reservoir would have a total storage capacity of 3,000 acre-feet and would be for flood control. Multiple-purpose storage of 2,110,000 acre-feet would be provided in 8 reservoirs having individual storage capacities greater than 25,000 acre-feet and 69 with individual storage capacities less than that amount.

Table 40 – WATER CONTROL AND RELATED LAND DEVELOPMENT, FRAMEWORK PLAN YELLOWSTONE SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SURFACE WATER CONTROL				
Storage	1,000 AF	289	659	2,113
Local Protection	Miles	14	20	20
Bank Stabilization	Miles	28	83	111
Grade Stabilization	Structures	14	84	194
LAND DEVELOPMENT				
Recreation, Fish and Wildlife	1,000 AC	34	70	93
Surface Water Irrigation				
Federal	1,000 AC	41	87	139
Non-Federal	1,000 AC	142	344	469
Public Land Conservation	1,000 AC	778	2,723	3,891

Of the 2,110,000 acre-feet of storage in multiple-purpose impoundments, 724,000 acre-feet would be inactive storage, 1,093,000 acre-feet would be joint use storage, and 293,000 acre-feet would be exclusive flood control storage. The joint use storage would be as follows:

Irrigation	921,000 acre-feet
Municipal & Industrial	85,000 "
Recreation, Fish & Wildlife	546,000 "
Flood Control	Incidental benefits from regulation

Local protection measures at Dubois, Lander, Thermopolis, Worland, Lovell, and Buffalo in Wyoming and Livingston, Miles City, Joliet, and Billings in Montana, involving 20 miles of stream improvements would be provided by the year 2000, while 111 miles of stream banks would be protected against erosion. Bank stabilization measures would be located primarily on the Bighorn, Powder, and Yellowstone rivers.

Land development features associated with the water control features of the subbasin framework plan include 93,000 acres of land around reservoirs, which would be used primarily for recreation and fish and wildlife purposes. An integral part of the surface water systems is the development of 608,000 acres of land for irrigation. Land conservation practices would be applied to 3,891,000 acres of federally owned land generally located in the forest areas of the mountainous part of the subbasin.

Environmental Enhancement and Non-Structural Measures

This element of the plan includes these additional environmental features not included in the previously described elements and which can be attained in response to the environmental objective. The same

Sugar Beets Frequently Are Grown On Irrigated Lands in Montana

viewpoints and considerations for non-structural measures outlined for the Upper Missouri Subbasin are applicable to the Yellowstone.

The environmental features included in the total subbasin framework plan include sufficient water and sewage treatment facilities to meet the needs in consonance with criteria outlined in preceding chapters; and the acquisition and development or management of 46,000 acres of wildlife area, four fish hatcheries, 315 miles of scenic rivers, two special use recreation areas, and 800 miles of trails. Other management programs include the preparation of 65 flood hazard reports covering 409,000 acres of flood-prone lands and forest and precipitation management programs that would increase average annual water yields by 145,000 and 536,000 acre-feet, respectively. Table 41 summarizes the features included in the environmental, non-structural element of the subbasin framework plan.

Table 41 – ENVIRONMENTAL ENHANCEMENT AND NON-STRUCTURAL MEASURES FRAMEWORK PLAN – YELLOWSTONE SUBBASIN

Feature	Unit	Amounts 1980	2000	2020
		(Cumulative Above Current)		
ENVIRONMENTAL				
Sewage & Treatment Plants[1]	Number	65	70	100
Water Supply & Treatment	1,000 AF/YR	454	635	1,085
Fish & Wildlife				
Management Areas	1,000 AC	11	25	46
Fish Hatcheries	Number	2	2	4
Scenic Rivers	Miles	0	315	315
Special Areas	Number	0	1	2
Trails	Miles	450	800	800
NON-STRUCTURAL				
Flood Plain Management				
Area	1,000 AC	11	25	409
Flood Hazard Reports	Number	5	15	65
Water Yield Increases				
Forest Management	1,000 AF	45	136	145
Precipitation Management	1,000 AF	89	267	536

[1] Includes existing plants.

Land and Water Changes

Net land use changes, as presented in table 42, reflect land requirements for transportation, urban and built-up areas, the conversions of nonirrigated agricultural land to irrigated croplands, and those lands required for structural and managerial plan features.

Water supply studies similar to those for the Upper Missouri Subbasin were made for the Yellowstone Subbasin in order to determine the consumptive use of all waters withdrawn or diverted for the various uses included in the subbasin framework plan. As was the case in the Upper Missouri, increased water yields from future management programs were treated as negative depletions to water supply, or as additions to the subbasin's total water supply.

Ground-water developments included in the subbasin framework plan are generally small, scattered, and confined mostly to alluvial areas adjacent to streams. Although withdrawals of ground water are largely equivalent to streamflow withdrawals, a ground-water depletion of 10 percent was assumed to recognize probable depletion of ground-water supplies for some areas where recharge may not be fully effective.

Table 43 presents water withdrawals for various uses and resulting depletions of streamflow and ground water. The average annual depletion of streamflows at the 2020 level approximates 1.5 million acre-feet, which recognizes an addition to streamflow of about 680,000 acre-feet from forestry and precipitation management programs.

Table 42 – LAND USE CHANGES, FRAMEWORK PLAN – YELLOWSTONE SUBBASIN

Principal Use	Net Land Use Changes 1965-1980	1980-2000	2000-2020	1965-2020
	(Thousand Acres)			
Irrigated Cropland	+180	+243	+135	+558
Non-irrigated Cropland	- 107	- 155	- 102	- 364
Forest and Woodland	- 60	- 113	- 146	- 319
Pasture and Range	- 272	- 428	- 458	- 1,158
Trans., Urban, & Built-up	+ 63	+105	+167	+335
Other (Rec., F&WL, & Other Uses)	+170	+315	+362	+847
Water	+ 26	+ 33	+ 42	+101

Table 43 – WATER WITHDRAWALS, DEPLETIONS, AND OTHER CHANGES FRAMEWORK PLAN – YELLOWSTONE SUBBASIN

Service	Withdrawals Ground 1980	2000	2020	Surface 1980	2000	2020	Depletions Ground 1980	2000	2020	Surface 1980	2000	2020
	(Cumulative Above Current – Thousand Acre-feet/Year)											
Irrigation	15	46	61	637	1,456	2,063	2	5	6	307	742	1,033
M&I, Rural Domestic	3	5	7	451	630	1,078	1	1	2	320	461	811
Thermal Power				293	706	778				8	42	88
Livestock	2	5	9	9	19	32	0	0	1	11	24	40
Land Conservation				5	10	17				5	10	17
Wetlands, Fish and Wildlife				11	27	49				11	27	49
Evaporation				47	94	136				47	94	136
Forest Management				- 45	- 136	- 145				- 45	- 136	- 145
Precip. Management				- 89	- 267	- 536				- 89	- 267	- 536
Total	20	56	77	1,319	2,539	3,472	3	6	9	575	997	1,493

Costs

Estimates of first costs and annual operation, maintenance, and replacement costs were made for all features of the subbasin framework plan. As shown in figure 23, total first costs approximate $1.7 billion and operation, maintenance, and replacement costs approximate $22.6 million annually by the year 2020.

First costs were distributed also to each functional item included in the subbasin framework plan in accordance with criteria presented in chapter 6. These are shown in figure 24 and, as can be noted, the largest share of the total investment would be for irrigation, at a cost of $630 million (37 percent), followed by recreation at a cost of $515 million (31 percent), and land conservation at a cost of $268 million (16 percent).

To provide a further insight to investment requirements, the distributed costs were further disaggregated to reflect Federal and non-Federal cost sharing relationships. Based on existing legal and policy considerations,

Table 44 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY — YELLOWSTONE SUBBASIN

	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
				(Non-Federal)				
Function	Total	Specific	Allocated Joint	Repayable	Cost-Share	Total	Fed. Grants & Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						7.3		7.3
State & Local Recreation						436.1	174.4	261.7
National Recreation Area								
Private Land Conservation						248.0	124.0	124.0
Irrigation Rehabilitation	60.5	60.5		60.5				
Access						.6		.6
Refuges								
Hatcheries	.7	.4			.3			
Reservoirs	9.9	9.9				35.9		35.9
Water Control and Related Land								
Single Purpose F. C.	11.9	9.5			2.4			
Other Single Purpose Res.								
Grade Stabilization	3.9	3.1			.8			
Bank Stabilization	3.3	2.4			.9			
M. P. Reservoirs	201.0	(71.5)	(129.5)	(103.4)				
Water Quality								
Irrigation			69.4	69.4				
M & I			9.5	9.5				
Power								
Recreation		49.0	25.3	24.5				
Fish and Wildlife			25.3					
Flood Control		22.5						
Surface Water Irrigation	104.3	104.3		104.3		351.3		351.3
Group Drainage								
Public Land Conservation	19.9	19.9						
Environ. and Non-Structural								
Sewage Treatment						36.0	10.8	25.2
Water Supply & Treatment						57.0	28.5	28.5
Fish and Wildlife								
Wetlands								
Management Areas						13.8	6.9	6.9
Fish Hatcheries	2.6	1.4			1.2			
Fish Impoundments								
Scenic Rivers	3.2	3.2						
Trails	.5	.5						
Flood Plain Management	1.2	1.2				59.4		59.4
Forest Management	.8	.8						
Precip. Management	19.9	19.9						
Totals	443.6	308.5	129.5	268.2	5.6	1,245.4	344.6	900.8
				1965-2020 Total: 1,689.0				

Table 45 – FRAMEWORK PLAN FOR 1980 – YELLOWSTONE SUBBASIN

Plan Feature	Description and Purpose	Initial First Costs			Annual Operation, Maintenance and Replacement Costs		
		Federal	Non-Fed	Total	Federal	Non-Fed	Total
		($ Million)			($ Thousand)		
Storage Reservoirs							
Modifications	Raise embankment of Tongue Reservoir on the Tongue River to provide 206,000 acre-feet of additional storage for irrigation and flood control and incidental values for fish, wildlife, and recreation.	0	35.9	35.9	0	217	217
Single-purpose Impoundments	Flood control reservoir with 3,000 acre-feet of storage for protection at Livingston, Mont.	0.4	0.1	0.5	0	5	5
Multi-purpose Impoundments, Major and Minor	Two impoundments having 100,000 acre-feet of storage and 21 minor reservoirs with a capacity of 186,000 acre-feet for irrigation, recreation, fish and wildlife, and flood control.	60.0	0	60.0	200	1,440	1,640
Irrigation							
New Systems and Rehabilitation	Provide 190,000 acres of irrigation subbasin-wide, consolidate 125 miles of ditches, line 166 miles of ditches, and drain 60,000 acres providing the equivalent of 33,000 new irrigated acres (subbasin-wide).	42.7	108.0	150.7	0	932	932
Local Flood Protection	Channel and levee improvements involving 14 miles for protection at Livingston, Miles City, and Joliet, Mont., and Dubois, Lander, Thermopolis, and Worland, Wyo.	3.6	0.9	4.5	0	40	40
Grade Stabilization	14 grade stabilization structures for erosion control.	0.2	0.1	0.3	0	2	2
Bank Stabilization	Bank protection on the Bighorn, Powder, and Yellowstone rivers covering 28 miles.	0.6	0.2	0.8	0	8	8
Recreation	The development of 131,000 acres by the State, local, and private sector, providing 20 new access sites to existing water and 450 miles of trails - generally throughout the subbasin.	35.7	53.2	88.9	0	806	806
Fish and Wildlife	11,000 acres for game management and two fish hatcheries in the subbasin.	2.3	2.2	4.5	0	13	13
Water Supply and Treatment	Treatment facilities to serve 69,000 people and development of individual supplies.	7.0	7.0	14.0	0	335	335
Sewage Treatment	Enlargement of 38 secondary facilities, additions to 18 secondary facilities, and construction of 9 new secondary facilities.	3.6	8.4	12.0	0	392	392
Water Yield Management	Forestry practices to yield 45,000 acre-feet of additional water and precipitation management to produce 89,000 acre-feet of additional water.	2.0	0	2.0	2	0	2
Land Conservation	Land treatment measures for 3,232,000 acres of private land and 778,000 acres of federally owned land.	35.4	31.5	66.9	38	2,000	2,038
Flood Plain Management	Preparation of 5 flood hazard reports covering 11,000 acres of flood plains.	0.1	7.1	7.2	6	35	41
Total		193.6	254.6	448.2	246	6,225	6,471

FIGURE 25

YELLOWSTONE SUBBASIN

PRINCIPAL WATER CONTROL FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

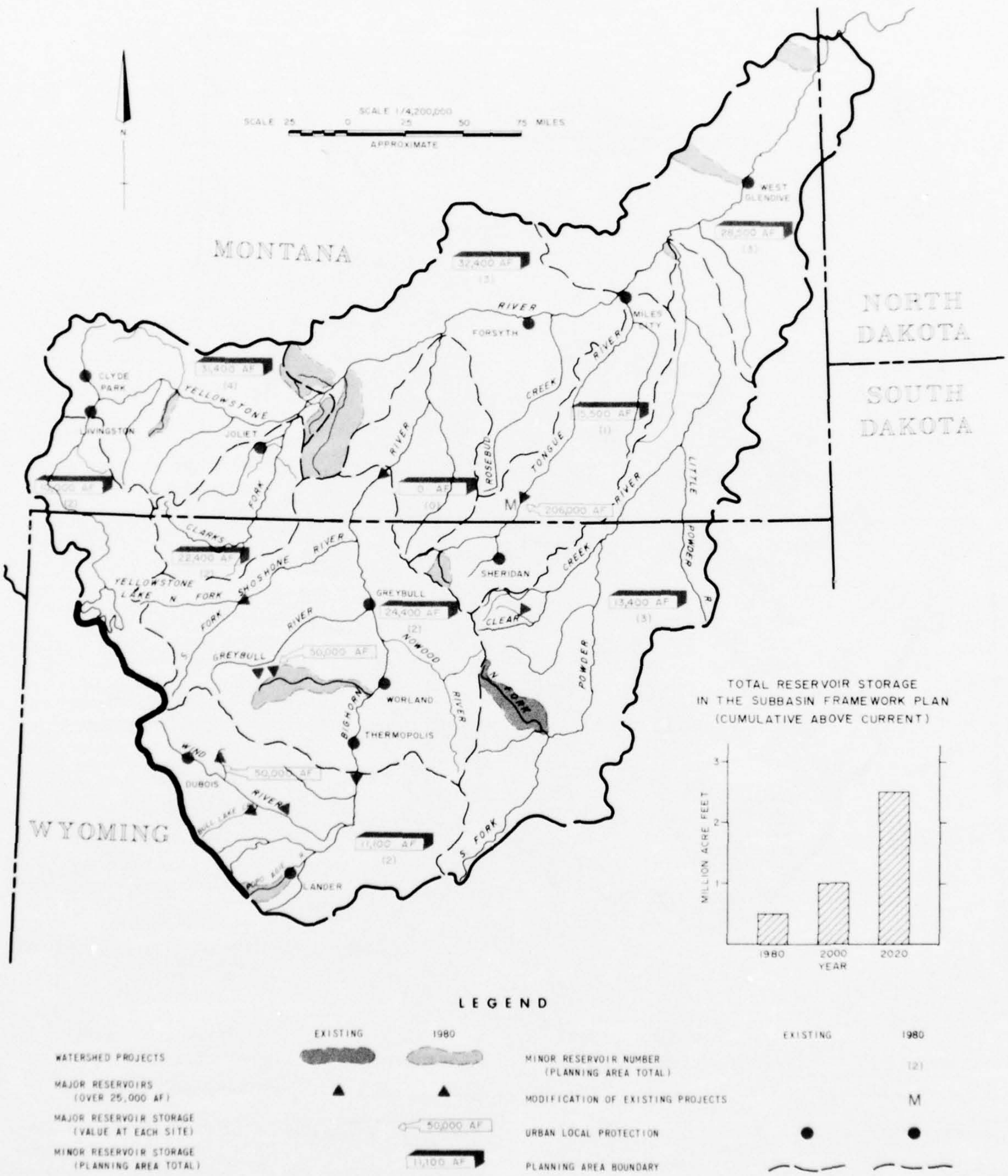


FIGURE 26

YELLOWSTONE SUBBASIN

RELATED LAND DEVELOPMENT FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

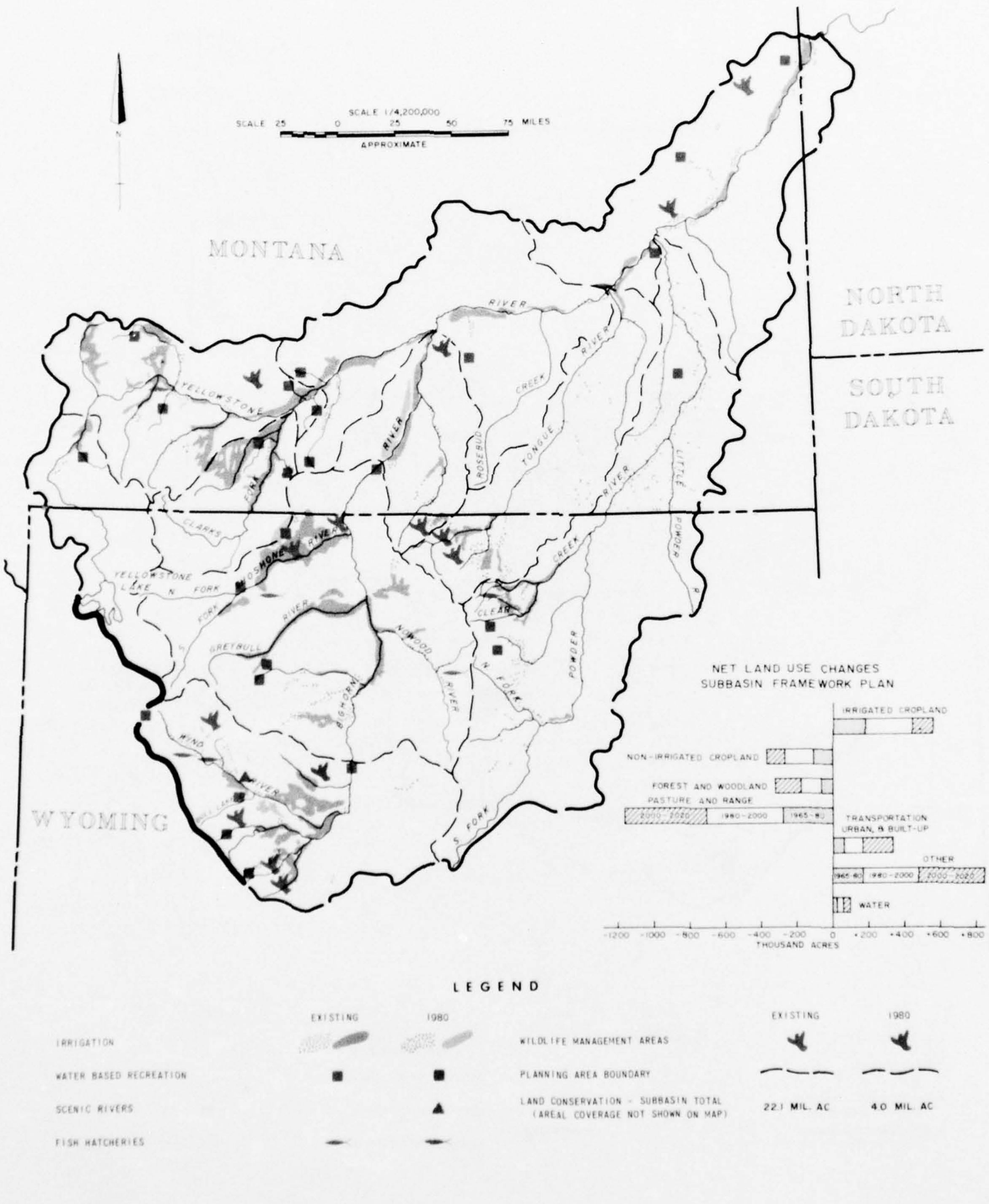
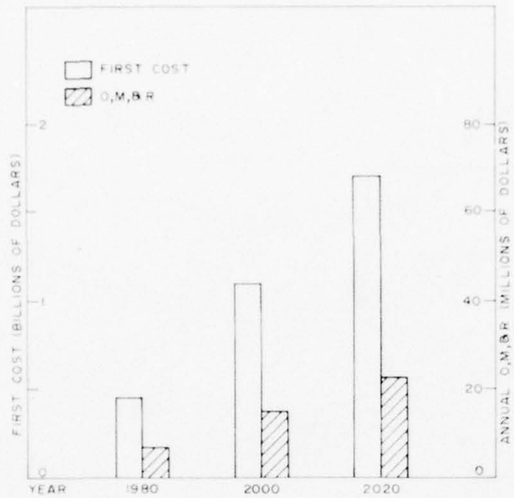


FIGURE 23
ESTIMATED FIRST COSTS AND
ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENTS
FRAMEWORK PLAN
YELLOWSTONE SUBBASIN
(cumulative above current)

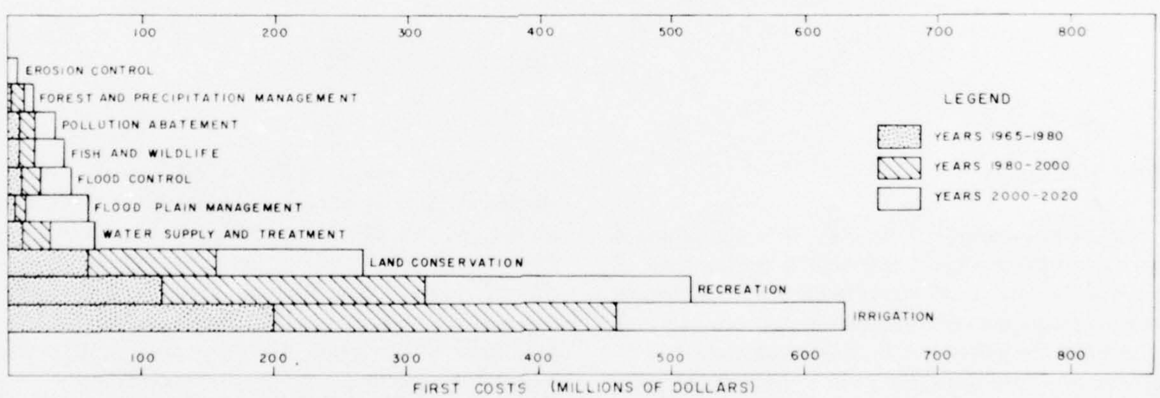


initial Federal investments of $438 million would be required. Of this amount, $268.2 million would have to be repaid over the long-term future by non-Federal entities as well as provide for $5.6 million as initial cost-sharing, resulting in a net Federal investment of $169.8 million. Similarly, the essentially non-Federal program, having a first cost of $1,245.4 million would be netted to $900.8 million through grant and assistance programs ($344.6 million) of the Federal Government. On the basis of initial investments, the cost sharing of the total framework plan would be on the order of 46 percent Federal and 54 percent non-Federal. Conversely, on the basis of net long-term costs, the cost-sharing would approximate 31 percent Federal and 69 percent non-Federal. The cost-sharing analyses are summarized in table 44.

Short-Range Framework Plan

Recognizing that projections of the future have diminishing accuracy and adequacy over the long-term, the short-range features of the total framework plan for this subbasin (to year 1980) have been disaggregated from the preceding material. Table 45 presents a concise description and selected pertinent data on the subbasin framework plan at the 1980 level. Figures 25 and 26 show principal elements of the 1980 framework plan by location.

FIGURE 24
DISTRIBUTION OF COSTS BY FUNCTIONAL PURPOSES
FRAMEWORK PLAN
YELLOWSTONE SUBBASIN



WESTERN DAKOTA SUBBASIN

The subbasin includes all right-bank tributaries of the Missouri River below the mouth of the Yellowstone River and above the mouth of the Niobrara River. It has a drainage area of about 77,100 square miles, with just over half of the area in South Dakota. The remainder of the subbasin is located in North Dakota (24 percent), Wyoming (15 percent), Montana (6 percent), and Nebraska (3 percent).

The subbasin is made up of two very different physiographic regions, the Black Hills and the Great Plains. The Black Hills are a mountainous upland covered by large tracts of conifer forest and drained by numerous, rather constantly flowing streams.

The Great Plains portion of the subbasin is composed mainly of several rolling tablelands, each separated from the others by a major stream valley. Large areas of the tablelands are much dissected by numerous dry draws and intermittent water courses.

Water Resources

The plains portion of the subbasin is a semi-arid region with the average annual rainfall ranging from 12 inches in the north to 19 inches in the south. The annual runoff averages between one-quarter and one-half inch for most of the plains, but fluctuates considerably with the wetness of the year. The annual yields of the plains streams generally vary directly with the annual precipitation within their basins since the surface runoff provides all but a small portion of the streamflows. Thus, the flows of the plains streams tend to be unpredictable and erratic as the annual precipitation follows uneven cycles of wet and drought.

Stream gaging records indicate that all of the plains streams have had periods of no measurable flow. Consequently, there have been times when no surface water was available for use except from storage. Unfortunately, these periods of no surface flow are most likely to occur in times of extended drought when the water is in greatest demand.

Because of the greater amount of rainfall and the accumulation of winter snow, the Black Hills have an average annual runoff of about 4 inches in their higher elevations. Many of the streams which drain the central portion of the hills have sustained base flows from ground water by way of numerous springs. Consequently, many of the Black Hills streams have higher, and maintain more constant, flows throughout the year than those in the plains. Also, they are not as directly affected by variations in the annual precipitation.

However, the flows from the Black Hills are significantly affected by a geologic peculiarity. Around the outer margin of the hills is a zone of porous limestone and sandstone outcrops. As the streams cross this zone, they lose substantial portions of their flows to the fractures and "sinkholes" which are characteristic of the rock formations. For some streams, the loss to the sinkholes amounts to their entire normal low flows.

The most important ground-water resource is a series of deep artesian acquifers found under most of the plains portion of the subbasin. The artesian pressure in the aquifers is generally great enough to raise the water to, or near, the land surface. Flows from the artesian formations are generally less than 15 gpm, but flows up to 500 gpm have been encountered. The artesian

aquifers have been extensively developed for rural and municipal water supplies and it appears from available records that the artesian head has decreased about 200 feet in the last 80 years.

Shallow ground-water supplies are largely limited to the alluvium in the major river valleys and to a few favored areas such as the Flint Hills of North Dakota. Locally, some of these supplies are extensively developed but their scattered occurrence limits their importance.

Ground water is scarce within the Black Hills with reliable aquifers occurring only in the alluvium of the stream valleys. However, some of the aquifers are good producers and several cities obtain their municipal supplies from them.

In 1965 there were 110 central water systems that served 186,000 people, which is about 62 percent of the 1960 population. There were 92 public sewerage systems, with 14 primary and 75 secondary waste treatment plants. Including many connected industries the total waste load in 1965 was 380,000 population equivalents which the treatment plants then existing reduced to 91,000 P.E. Many of the streams flow intermittently which complicates the handling of effluents from municipal waste treatment facilities. Most of the serious water quality problems caused by urban areas and industries occur along the lower reaches of the Black Hills streams.

At present very few industrial inorganic wastes are treated by municipal treatment plants, and large quantities of inorganic wastes also are discharged untreated. Some of the streams of the Black Hills region have been severely degraded by mining and timbering operations. Restoration of Whitewood Creek, which carries wastes from the Homestake Mine and other industrial operations, presents a great challenge for better stream water quality.

Return flows from 209,000 acres of irrigated lands carry agricultural chemicals and other dissolved solids back to the streams. While there are several large thermal-electric plants on the Missouri River in this area, the amount of water available for cooling makes thermal pollution of little or no consequence. Wastes from oil and gas fields are under strict surveillance.

Sediment has contributed significantly to the degradation of the fisheries in about 244 miles of the Cheyenne River, 196 miles of the Belle Fourche River, and 5 miles of the North Fork of Castle Creek in South Dakota. Additional reaches of other streams are affected to some extent.

The streamflow leaving the subbasin is that contributed to the Missouri River by four major and several minor tributary streams. Limited quality of water data have been obtained for only a few of the streams; therefore a composite estimate of the dissolved solids concentration in the streamflows leaving the basin could not be estimated. Data available for the Cheyenne River show a dissolved solids concentration of about 1,000 mg/l. Based on this analysis the indications are that the dissolved solids concentration in the streamflows leaving the subbasin are high. Most of the dissolved solids are those in the natural runoff as there are return flows from only 209,000 acres of irrigation and a relatively minor amount from municipal and industrial effluents.

Flood and Erosion Control

There are 14 existing major projects providing flood control within the subbasin together with several local, smaller protection projects. There is some degree of flood protection for about 84,000 acres of land, including six urban areas. The estimated reduction in average annual damages is about $867,000, or 27 percent of the total.

Some urban areas, particularly Rapid City, Sturgis, Spearfish, Belle Fourche, Marmarth, and Mandan, still face severe flooding hazards. In some of these areas, existing local protection works and flood storage are insufficient to provide a desirable level of protection. Also, there are some 1.3 million acres of agricultural land subject to varying flood hazards.

Serious streambank erosion occurs along the Knife, Heart, Bad, White, and Missouri rivers with 1,970 bank-miles, or about one percent of the existing channel banks, receiving serious erosion. Average annual losses due to streambank erosion are estimated to be $454,000.

Gully erosion is widespread and it affects a substantial portion of the total land surface. The large zones of broken land and badlands that flank the major streams as well as the large sediment loads of the streams are mute testimony of the amount of erosion that is taking place. Most of this erosion is the result of natural phenomena. However, farming and grazing practices are contributing factors. In most places, the erosion that is caused by man's activities and the geologic erosion that would occur naturally is impossible to separate to any fine degree. At present, there are no remedial programs large enough in scope to significantly reduce natural or geologic erosion.

Under existing land treatment programs, it is estimated that only about 344 acres of land damaged each year by voiding and depreciation by gullies are susceptible to project type action. The average annual damages are estimated to be $39,000.

Water Supply

Currently, there are over 200,000 acres of land provided full service irrigation. This includes the lands irrigated under the six major Federal projects and a large number of small group and individual developments.

The Picturesque Badlands Result From Natural Erosion

Approximately one-half of the total irrigation has been developed by private interests. In the Black Hills, the bulk of the private irrigation is accomplished by the use of mutual canals. On the plains, the private irrigation is accomplished by pumping from live streams or by diverting water from small storage dams on intermittent water courses. The efficiency of the private systems ranges from poor to very good, depending upon the management supplied by the operators.

The various Federal irrigation projects are presently developed almost to the limit of their water and land resources, with the exception of Shadehill Reservoir in South Dakota and the main stem Missouri River reservoirs. The authorized 6,700-acre irrigation project to be supplied water from Shadehill Reservoir has not been implemented. Under present economic and physical conditions, none of the Federal projects have much potential for expansion. Perhaps the most limiting factor to any expansion is the lack of additional dependable water supplies within the present storage capacities.

The problems of private irrigation developments and some of the Federal projects have been adverse soil and water conditions. Many of the drainage and salinity problems could be greatly reduced with the application of better irrigation practices.

The use of water-spreading devices to irrigate hay and pasture lands is one of the fastest growing developments within the subbasin. Currently, there are approximately 198,000 acres irrigated by uncontrolled water-spreading devices.

Ground water is the principal source of municipal and industrial water in the subbasin. Even though the quality is often poor, it is usually the cheapest source to develop. About 137 towns and industries in the subbasin have individual or central water systems. Of this number, about 40 percent is reported to have water quality that does not conform with the recommended United States Public Health Service drinking water standards. Most of the ground-water supplies exceed the limits for total dissolved solids and several exceed the limits for sodium, iron, and sulfates.

Many urban areas face periodic water shortages but generally this is due to inadequate treatment or distribution systems rather than a lack of a raw water supply. A few of the larger urban areas whose populations are increasing rapidly will be facing water shortages and will need expanded supplies in the near future; Rapid City and Dickinson are prime examples.

Ground water is also the predominant source of water for rural domestic use. In large areas of the plains, rural

domestic supplies are available only from the deep artesian aquifers. Generally, the subbasin has adequate amounts of water for rural domestic uses but the quality is often poor.

Historically, the development of a rural domestic supply has been wholly an individual undertaking. Recently, there have been two developments to help the individual secure a better water supply in some rural areas. First, the U. S. Public Health Service has undertaken a program of well drilling and the installation of sanitary water systems on the Indian reservations, and second, a program of providing financial and technical assistance by Federal agencies has led to the development of rural cooperatives water systems. The latter could prove quite beneficial in the few areas of dense rural settlement found in the subbasin.

Surface-water supplies are by far the most important for livestock purposes. The bulk of the stock water is provided by about 56,000 small ponds for livestock water. In addition, there are many similar structures that primarily serve irrigation, wildlife, and recreation purposes.

Electric Power Generation

In 1965, there were five steam-electric plants that produced 10 megawatts of power or more within the subbasin. In addition, parts of the subbasin are supplied with power from the Missouri River hydroplants.

The potential for future development of hydroelectric power in the subbasin is very limited. Plants powered with fossil fuels will likely provide for any increased demands. In 1965, steam-electric plants diverted about 49 thousand acre-feet of water annually for cooling purposes of which about 2,300 acre-feet were consumed.

Fish, Wildlife, and Recreation

Currently, there are about 956,000 acres of land and about 49,200 acres of water and wetland primarily devoted to fish and wildlife uses in the subbasin. Annual water consumption in these areas is estimated to be 17,260 acre-feet.

The subbasin has a large surplus of fishing capacity, most of which is provided by the large mainstem reservoirs. Present use accounts for about 23 percent of the total fisheries capacity. In addition to its share of the mainstem reservoirs, the subbasin has good warm-water fisheries on its smaller tributary reservoirs and farm ponds. The cold-water fisheries of the subbasin are limited to the Black Hills and provide about 9 percent of the estimated fishing capacity. The trout streams of the Black Hills are much more heavily used than the other fishing waters and cannot meet current demands.

The present hunting demand represents approximately 30 percent of the total capacity of the subbasins. The area lacks natural waterfowl habitat, but waterfowl populations have made substantial gains in recent years due to the availability of stock ponds.

The large federally owned areas within the subbasin account for slightly less than 50 percent of both the total and developed lands, 96 percent of the waters, and the bulk of the most significant recreation opportunities. State recreation areas and state administered areas on the mainstem reservoirs provide highly significant opportunities for outdoor recreation and a large share of the developed lands. Locally developed recreation areas include only a fraction of the total land but about 15 percent of the developed areas. Private areas are even more significant, especially in the Black Hills area, as they furnish about 25 percent of the developed recreation lands found in the subbasin.

Subbasin residents and those living in urban areas near the subbasin generate about 39 percent of the current recreation demand. The Black Hills area and the Theodore Roosevelt National Memorial Park attract millions of tourists each year, many of whom are non-residents.

Tourism, including hunting and fishing, is probably the second most important industry throughout the subbasin. In many areas, it is the only viable economic alternative to agriculture. The subbasin has a number of locales that have great scenic, recreational, hunting, and fishing potentials. One of the needs is for the development of these favored areas.

Land Conservation and Drainage

Currently, 9.3 million acres of the privately owned lands in the subbasin are used for crop production, 31.7 million acres are used for pasture and range, 977 thousand acres are in forest and woodlands, 209 thousand acres are in other agricultural uses, and 771 thousand acres are in nonagricultural uses. About 198 thousand acres of cropland and 11 thousand acres of pasture and range are irrigated annually. About 5.1 million acres of Federal land are used for agricultural purposes, 3.9 million are grazed, and 1.5 million produce forest products. An additional 824 thousand acres of Federal land are used for nonagricultural purposes.

Of the 9.3 million acres used for cropland, 87 percent, or 8.1 million acres are suitable for sustained cultivation with proper management and conservation measures. The remaining 1.2 million acres of cropland are not suitable for continuous cultivation without sustaining damage to the soil resources. Conversely, about 4.9 million acres of pasture and range are physically suitable and can be used for sustained crop production with proper management and conservation measures.

Wind and water erosion damage seriously affect lands in the subbasin. Through their own efforts and with Federal technical assistance and cost-sharing available to them, the owners and operators have installed adequate conservation treatment and management on 20.3 million acres of the private agricultural lands. Management-type practices on 15.8 million acres and mechanical or vegetative-type practices on 6.9 million acres are needed to provide adequate levels of conservation treatment and management.

On federally owned lands, 64 percent, or 3.8 million acres are currently adequately treated and managed. The remaining 2.1 million acres in the subbasin need improved conservation treatment and management for sustained use without deterioration.

There are approximately 894 thousand acres of agricultural land in the subbasin subject to excess water problems. This is exclusive of the 2 thousand acres of land with an excess water problem caused by irrigation water that is included in irrigation systems. Currently, 52 thousand acres of cropland have been provided with adequate drainage. Of the remaining 842 thousand acres subject to excess water, 149 thousand acres are considered potentially suitable and feasible to drain. An additional 137 thousand acres of pasture and range and 12 thousand acres of forest and woodland are subject to problems of excess water and are suitable for conversion to cultivated uses. About 19,000 acres will require project-type measures to remove excess water.

About 690 thousand acres, or 77 percent of the land with excess water problems are considered infeasible to drain. Of this total, 33 thousand acres are currently used for cropland and should be converted to non-crop uses. This and the remainder should be used for grazing and woodlands and managed to utilize its natural value as wildlife habitat.

Planning Objectives

This subbasin has some rather special physical and social characteristics in addition to its economic matrix. Such a combination makes the area unique in comparison with other areas of the region. The natural environment is a major factor in the economic activities of the subbasin. Even though man has been able to master some of the environmental hazards, his livelihood is still dependent largely on the whims of nature. He has not yet progressed to the stage where he can re-make nature to fit his economic goals.

Since frontier days, the plains portion of the subbasin has been dominated by an agricultural economy, particularly stock raising. At the present time, there is no indication of either an economic change or a technical innovation that will significantly alter the basic livestock economy of the plains.

Vast deposits of lignite underlie the plains area in southwestern North Dakota. Here exists a significant potential for industrial development, especially thermal-electric power production, through the use of a virtually untapped fuel resource.

In the western part of the subbasin, the Black Hills area has a more diverse basic economy than does the rest of the subbasin. Here the past and present economic base has shifted between various mixes of agriculture, mining, timber, manufacturing, and tourism. Present indications are that the tourist industry will become the more important segment of the economy in the Black Hills area.

For the areas within the subbasin, as described, three principal planning objectives emerge. First is the need for productivity increases throughout the subbasin. The effects of rising production costs and constant or declining prices for products from agriculture and mining are well known. At present, it appears that the increasing of productivity is about the only way these industries can maintain a reasonable profit margin.

Secondly, there is a need for income stabilization, particularly in agriculture, mining, and tourism. Agriculture regularly experiences wide fluctuations of income due to such environmental factors as droughts – which often are quite extreme. Mining has had many ups and downs in the past and currently is in a rather depressed state. This is attributed primarily to the depletion of high grade ores and shifts in demands for various minerals. An exception is the mining of lignite which appears to be emerging toward rather rapid future expansion. Tourism is a seasonal enterprise, limited almost entirely to the three summer months. Even though the tourist industry has exhibited recent growth, yearly fluctuations in income from tourism are being experienced in some localities.

The third major planning goal deals with poverty areas within the subbasin. A large number of counties have a mean annual family income of less than $3,000. The Indian population, especially, has a very low per capita income. In many areas of the subbasin, basic social services must be heavily supported by either State or Federal governments because of the inadequacy of local tax revenues. There is reason to believe that in some localities there is a widening gap between their standards of living and the national average. The possibility exists that rural poverty could become an extremely serious problem in the subbasin.

At least portions of the socio-economic problems of the subbasin may be solved by water resource development. It is not the purpose of this study to explore all alternatives to the socio-economic problems of the region, but rather to explore the alternatives relative to water resource development. For this subbasin, alternatives are limited by the scarce available water supply and the limiting constraints of climate, topography, and

soils. Accordingly, a framework plan was formulated that would enhance the general economic structure of the various parts of the subbasin and founded on the natural attributes of these parts. From this concept the plan is oriented toward agricultural stability and enhancement, lignite development, and environmental enhancement to promote tourism.

Specified Non-Federal Programs and Modifications of Existing Developments

It is anticipated that private ground-water development will be accelerated following a modest start during the next 10 years. This is attributed to a reliance on surface-water supplies which will become scarcer over the long term. Further development of recreation areas by the State, local, and private sectors will continue, primarily in the Black Hills area. The extent of such development has been projected on the basis of anticipated needs. Land conservation programs are expected to continue into the future generally as they have in the past.

Modifications of existing developments include a modest improvement in existing irrigation systems within the concept of efficiency gains; a 6,000 acre-foot increase in the capacity of the existing Dickinson Reservoir to provide for additional water supply needs at Dickinson, N. Dak.; the expansion and improvement of an existing wildlife refuge and a fish hatchery; and the provision of additional recreational access and establishment of a proposed national recreation area along the main stem reservoirs on the Missouri River. Table 46 presents quantified values for these elements of the framework plan for the Western Dakota Subbasin.

Table 46 – SPECIFIED NON-FEDERAL PROGRAMS AND MODIFICATIONS OF EXISTING DEVELOPMENTS, FRAMEWORK PLAN – WESTERN DAKOTA SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SPECIFIED NON-FEDERAL PROGRAMS				
Private Ground-Water Irrigation	1,000 AC	7	39	119
State, Local, and Private Recreation	1,000 AC	114	418	600
Private Land Conservation	1,000 AC	4,050	10,310	14,054
MODIFICATIONS OF EXISTING DEVELOPMENTS				
Irrigation System Improvements				
Ditch Consolidation	Miles	21	21	22
Ditch Lining	Miles	2	13	14
Reservoirs	1,000 AF	0	6	6
Fishing and Recreation Access	Number	79	157	157
National Recreation Area	1,000 AC	19	39	39
Fish Hatchery	Number	1	1	1
Refuge Additions	Number	1	1	1

Facilities Such As These Would Be Included In The Great Prairie Lakes National Recreation Area

Water Control and Related Land Development

The magnitude of the water and related land development features of the framework was determined recognizing the constraints of water availability, economic efficiency gains, and the planning objectives pertinent to the subbasin. It is recognized that in every planning area within the subbasin various alternatives could be developed for comparative purposes, but in this case it would merely be an academic exercise. For example, adoption of a planning objective to intensify agriculture in the plains areas, or to enhance recreational-environmental opportunities in the Black Hills area not only dictates the composition of the framework plan for these areas, but reflects the overall constraints that the economy of certain areas cannot be "remade" to something that cannot be supported. On this basis, table 47 presents quantified values for the water and related land development component of the framework plan for the subbasin.

Table 47 – WATER CONTROL AND RELATED LAND DEVELOPMENT, FRAMEWORK PLAN
WESTERN DAKOTA SUBBASIN

Feature	Unit	Amounts 1980	2000	2020
		(Cumulative Above Current)		
SURFACE WATER CONTROL				
Storage	1,000 AF	797	2,446	2,827
Local Protection	Miles	12	12	12
Bank Stabilization	Miles	33	100	133
Grade Stabilization	Structures	23	44	44
LAND DEVELOPMENT				
Recreation, Fish and Wildlife	1,000 AC	15	76	160
Group Drainage	1,000 AC	8	9	9
Surface Water Irrigation				
Federal	1,000 AC	29	99	136
Non-Federal	1,000 AC	120	228	507
Public Land Conservation	1,000 AC	108	1,134	1,620

A Variety of Recreation Activities In The Scenic Black Hills

The surface water control features for the total framework plan include 71 multiple-purpose reservoirs having a total storage of 2,823,000 acre-feet. This amount of storage would be developed in 7 reservoirs having individual storage capacities of greater than 25,000 acre-feet, with the remaining 64 reservoirs having individual storage capacities of less than 25,000 acre-feet. In addition, 2,000 acre-feet of single-purpose flood control storage would be provided for local protection at Rapid City, S. Dak., and 2,000 acre-feet in small impoundments for fish and wildlife purposes.

Of the 2,823,000 acre-feet in multiple-purpose impoundments, 82,000 acre-feet would be inactive storage, 1,813,000 acre-feet would be for joint beneficial uses, and 928,000 acre-feet would be for exclusive flood control. The joint use storage would be used as follows:

Irrigation	1,796,000 acre-feet
Municipal & Industrial	13,000 "
Recreation, Fish & Wildlife	906,000 "
Flood Control	Incidental benefits from regulation

About 12 miles of stream improvements would be provided for local flood protection at Medora, Beulah, Stanton, and Almont in North Dakota and Belle Fourche and Fort Pierre in South Dakota. Other in-stream controls would include 133 miles of bank erosion control located primarily on the Cheyenne, White, and Little Missouri rivers and 44 grade stabilization structures to control gullying.

The land development related to the water control facilities would include 160,000 acres for recreation and fish and wildlife uses; about 9,000 acres of public or group drainage systems; and the irrigation of 643,000 acres of land from surface sources including Indian projects. Land conservation practices would be applied to over 1.6 million acres of federally owned lands.

Concrete-Lined Ditches Conserve Water For Irrigation

Environmental Enhancement and Non-Structural Measures

Other environmental enhancements not included in the preceding features of the framework plan, but an

integral part of the plan, were also delineated. Non-structural measures applicable to the subbasin were also outlined for the framework. The features for this component of the subbasin framework plan were based on the same consideration outlined for the previous subbasins. Table 48 summarizes the extent and magnitude of these features.

Table 48 – ENVIRONMENTAL ENHANCEMENT AND NON-STRUCTURAL MEASURES FRAMEWORK PLAN – WESTERN DAKOTA SUBBASIN

Feature	Unit	Amounts 1980	2000	2020
		(Cumulative Above Current)		
ENVIRONMENTAL				
Sewage Treatment Plants[1]	Number	110	120	200
Water Supply and Treatment	1,000 AF/YR	23	44	74
Fish and Wildlife				
Management Areas	1,000 AC	5	10	21
Fish Hatcheries	Number	1	1	1
Fish Impoundments	Number	3	6	12
Special Areas	Number	9	17	17
Trails	Miles	195	390	390
NON-STRUCTURAL				
Flood Plain Management				
Area	1,000 AC	2	37	173
Flood Hazard Reports	Number	4	19	51
Water Yield Increases				
Forest Management	1,000 AF	0	8	8

[1] Includes existing plants.

The environmental features of the subbasin framework plan include sufficient water and sewage treatment facilities to meet future needs and are in consonance with criteria outlined in preceding chapters; the acquisition, development, or management of 21,000 acres for wildlife, and one fish hatchery and 12 fishing impoundments; and 17 special use recreation areas, and 390 miles of trails. Other management programs include the preparation of 51 flood hazard reports covering 173,000 acres of flood plain lands and a forest management program that would yield an average of 8,000 acre-feet of water annually.

Table 49 – LAND USE CHANGES, FRAMEWORK PLAN – WESTERN DAKOTA SUBBASIN

Principal Use	Net Land Use Changes 1965-1980	1980-2000	2000-2020	1965-2020
	(Thousand Acres)			
Irrigated Cropland	+155	+208	+394	+757
Non-irrigated Cropland	-170	-219	-428	-817
Forest and Woodland	- 18	- 16	- 13	- 47
Pasture and Range	-143	-221	-173	-537
Transportation, Urban & Built-up	+ 46	+ 73	+105	+224
Other (Rec., F&WL, and Other Uses)	+109	+145	+101	+355
Water	+ 21	+ 30	+ 14	+ 65

Table 50 – WATER WITHDRAWALS, DEPLETIONS, AND OTHER CHANGES FRAMEWORK PLAN – WESTERN DAKOTA SUBBASIN

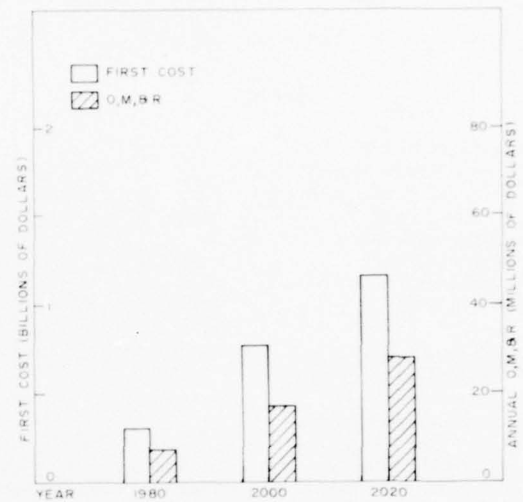
Service	Withdrawals Ground 1980	2000	2020	Surface 1980	2000	2020	Depletions Ground 1980	2000	2020	Surface 1980	2000	2020
	(Cumulative Above Current – Thousand Acre-feet/Year)											
Irrigation	9	49	158	512	1,083	1,948	7	39	121	216	457	823
M&I, Rural Domestic	13	26	47	10	18	27	4	8	15	3	6	9
Thermal Power				249	313	349				15	30	53
Livestock	6	12	20	13	26	45	6	12	20	13	26	45
Land Conservation				20	63	112				20	63	112
Evaporation				79	181	231				79	181	231
Forest Management				0	-8	-8				0	-8	-8
Total	28	87	225	883	1,676	2,704	17	59	156	346	755	1,265

Land and Water Changes

Net land use changes that would result from the subbasin framework plan reflect land conversions for the same categories of use described previously for the Upper Missouri and Yellowstone subbasins. The net land use changes are presented in table 49.

Data on water withdrawals for the various purposes in the subbasin framework plan and the resultant depletions of stream and ground-water supplies were compiled in the same manner as described for the preceding subbasins. Depletions, or mining, of ground water, however, are somewhat higher than in the subbasins previously described. Recharge of ground-water aquifers will vary throughout the subbasin. Ground-water depletions were estimated to range from 10 to 20 percent of withdrawals for the various planning areas within the subbasin. Table 50 presents the withdrawal and depletion values for the Western Dakota Subbasin framework plan.

FIGURE 27
ESTIMATED FIRST COSTS AND
ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENTS
FRAMEWORK PLAN
WESTERN DAKOTA SUBBASIN
(cumulative above current)



Costs

Estimates of first costs and annual operation, maintenance, and replacement costs (OM&R) for all features of the subbasin framework plan indicate a total investment requirement of about $1.2 billion. Average annual OM&R costs could range from $7.7 million by 1980 to $28.1 million by 2020. Figure 27 presents cost estimates for the subbasin framework plan at the 1980, 2000, and 2020 target years.

The first costs distributed to each functional item included in the subbasin framework plan are shown graphically in figure 28. As can be noted from figure 28, the largest share of the total investment would be for land conservation, $344 million (29 percent), followed by irrigation, having a cost of $300 million (25 percent), and recreation, with a cost of $266 million (22 percent).

Further insight to investment requirements is provided by an additional disaggregation of costs to reflect not only functional uses, but also the Federal – non-Federal cost-sharing relationships. Based on existing legal and policy considerations, initial Federal investments of $446.8 million would be required. Of this amount, $210.3 million would have to be repaid over the long-term future by non-Federal institutions as well as provide $5 million for initial cost-sharing, resulting in a net Federal investment of $236.5 million. Similarly, non-Federal programs having a first cost of $735.4

FIGURE 28
DISTRIBUTION OF COSTS BY FUNCTIONAL PURPOSES
FRAMEWORK PLAN
WESTERN DAKOTA SUBBASIN

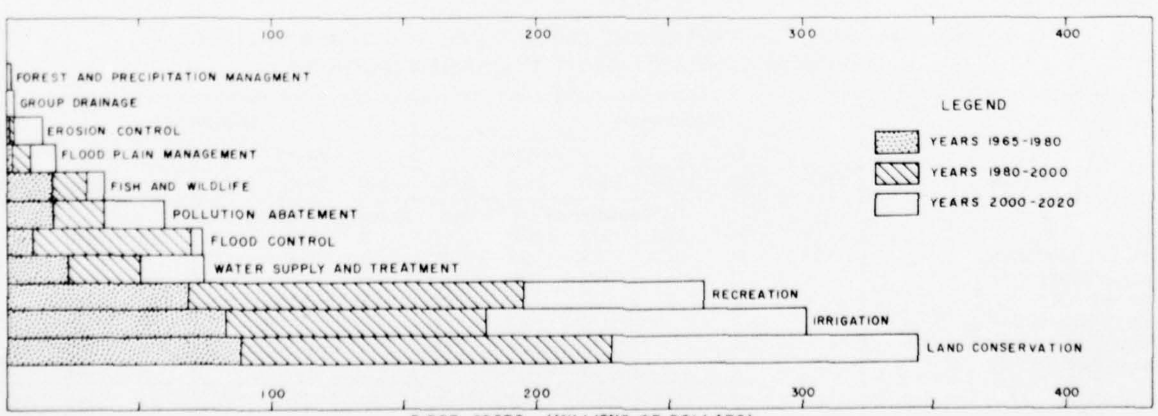


Table 51 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY – WESTERN DAKOTA SUBBASIN

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						23.8		23.8
State & Local Recreation						129.6	51.8	77.8
National Recreation Area	27.9	27.9						
Private Land Conservation						330.0	165.0	165.0
Irrigation Rehabilitation	6.9	6.9		6.9				
Access						.2		.2
Refuges	2.0	2.0						
Hatcheries	.5	.3			.2			
Reservoirs	.6	.6						
Water Control and Related Land								
Single Purpose F. C.	2.2	1.8			.4			
Other Single Purpose Res.						.2		.2
Grade Stabilization	10.7	8.5			2.2			
Bank Stabilization	3.2	2.3			.9			
M. P. Reservoirs	315.0	(138.7)	(176.3)	(148.9)				
Water Quality								
Irrigation			113.7	113.7				
M & I			1.2	1.2				
Power								
Recreation		67.0	30.7	33.5				
Fish and Wildlife		1.0	30.7	.5				
Flood Control		70.7						
Surface Water Irrigation	54.5	54.5		54.5		101.4		101.4
Group Drainage	1.1	.6		.5				
Public Land Conservation	14.3	14.3						
Environ. and Non-Structural								
Sewage Treatment						59.0	17.7	41.3
Water Supply & Treatment						72.0	36.0	36.0
Fish and Wildlife								
Wetlands								
Management Areas						1.6	.8	.8
Fish Hatcheries	1.1	.6			.5			
Fish Impoundments								
Scenic Rivers	.6	.3			.3			
Trails	10.1	10.1						
Flood Plain Management	1.0	1.0				17.6		17.6
Forest Management	.1	.1						
Precip. Management								
Totals	451.8	270.5	176.3	210.3	5.0	735.4	271.3	464.1
				1965-2020 Total: 1,187.2				

Table 52 – FRAMEWORK PLAN FOR 1980 – WESTERN DAKOTA SUBBASIN

Plan Feature	Description and Purpose	Initial First Costs			Annual Operation, Maintenance and Replacement Costs		
		Federal	Non-Fed	Total	Federal	Non-Fed	Total
		($ Million)			($ Thousand)		
Storage Reservoirs Single-purpose Impoundments	A flood control reservoir with 2,000 acre-feet of storage for protection at Rapid City, S. Dak. and a fish and wildlife reservoir with 2,000 acre-feet of storage	0.6	0.4	1.0	0	5	5
Multiple-purpose Impoundments Major and Minor	Eighty-nine minor reservoirs with a capacity of 793,000 acre-feet for irrigation, M&I, recreation, fish & wildlife, and flood control.	105.0	0	105.0	762	749	1,511
Irrigation New Systems and Rehabilitation	Provide 156,000 acres of irrigation subbasin-wide, consolidate 21 miles of ditches and line 2 miles of ditches providing the equivalent of 1,000 new irrigated acres.	9.6	25.4	35.0	0	1,063	1,063
Group Drainage	Provide 8,000 acres of public or group drainage.	0.5	0.4	0.9	0	18	18
Local Flood Protection	Channel and levee improvements involving 12 miles for protection at Medora, Beulah, Stanton, and Almont, N. Dak. and Belle Fourche and Fort Pierre, S. Dak.	1.2	0.2	1.4	0	9	9
Grade Stabilization	23 grade stabilization structures for erosion control.	0.3	0.1	0.4	0	5	5
Bank Stabilization	Bank protection on the Cheyenne, White, and Little Missouri rivers covering 33 miles.	0.6	0.2	0.8	0	8	8
Recreation	The development of 19,000 acres for a national recreation area along the main stem reservoirs and 114,000 acres by the State, local, and private sector, providing 79 new access sites to existing water, and 195 miles of trails (NRA).	28.5	14.4	42.9	190	734	924
Fish and Wildlife	5,000 acres for game management, a 10,000-acre addition to an existing refuge, and one new fish hatchery, one modification, and three fish impoundments.	3.2	1.0	4.2	20	137	157
Water Supply and Treatment	Treatment facilities to serve 72,000 people and development of individual supplies.	10.5	10.5	21.0	0	240	240
Sewage Treatment	Enlargement of 75 secondary facilities, additions to 14 secondary facilities, and construction of 21 new secondary facilities.	5.4	12.6	18.0	0	540	540
Land Conservation	Land treatment measures for 4,050,000 acres of private land and 108,000 acres of federally owned lands.	48.4	45.5	93.9	168	3,000	3,168
Flood Plain Management	Preparation of 4 flood hazard reports covering 2,000 acres of flood plains.	0.1	0.2	0.3	1	1	2
Total		213.9	110.9	324.8	1,141	6,509	7,650

FIGURE 29

WESTERN DAKOTA SUBBASIN

PRINCIPAL WATER CONTROL FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

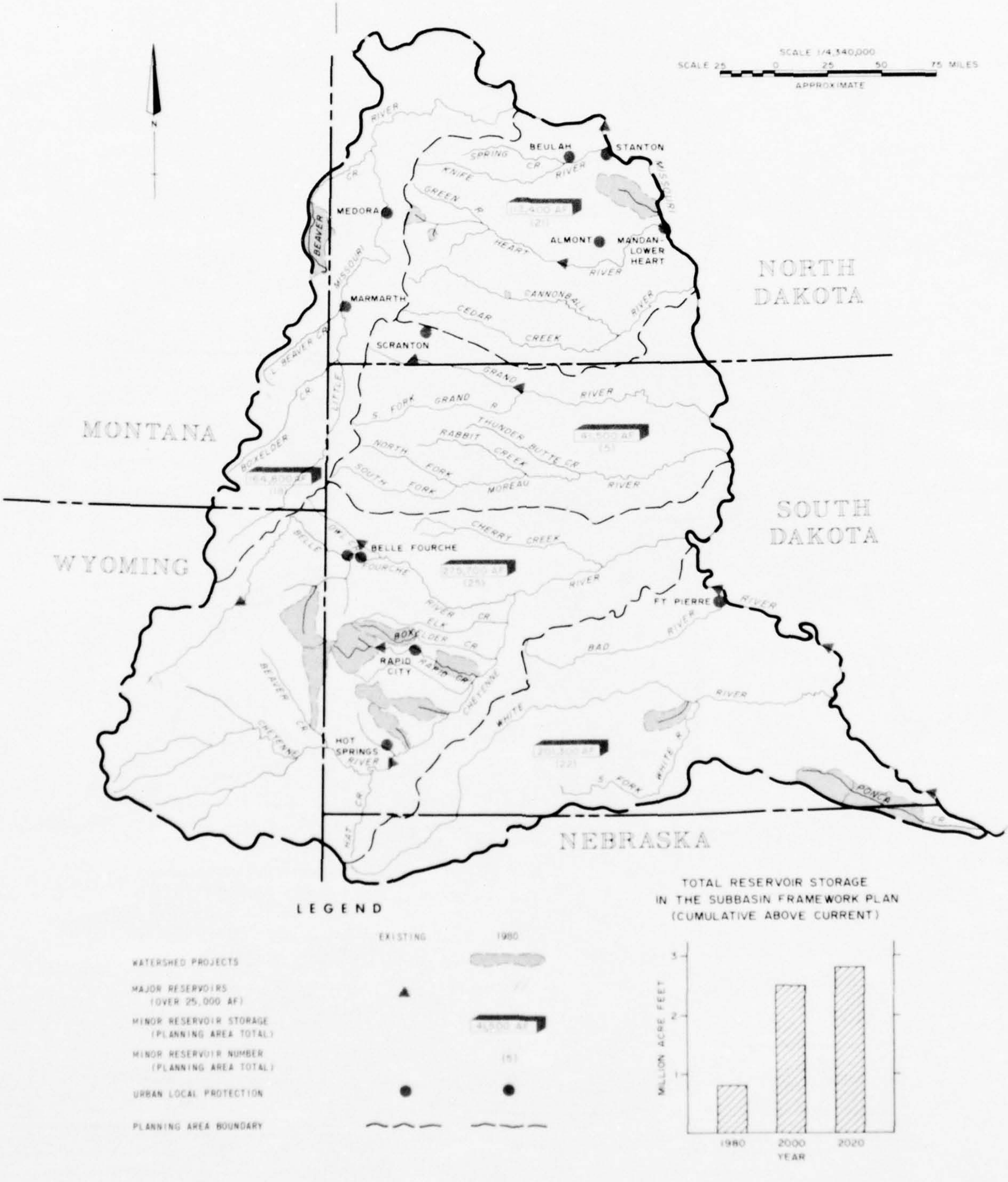
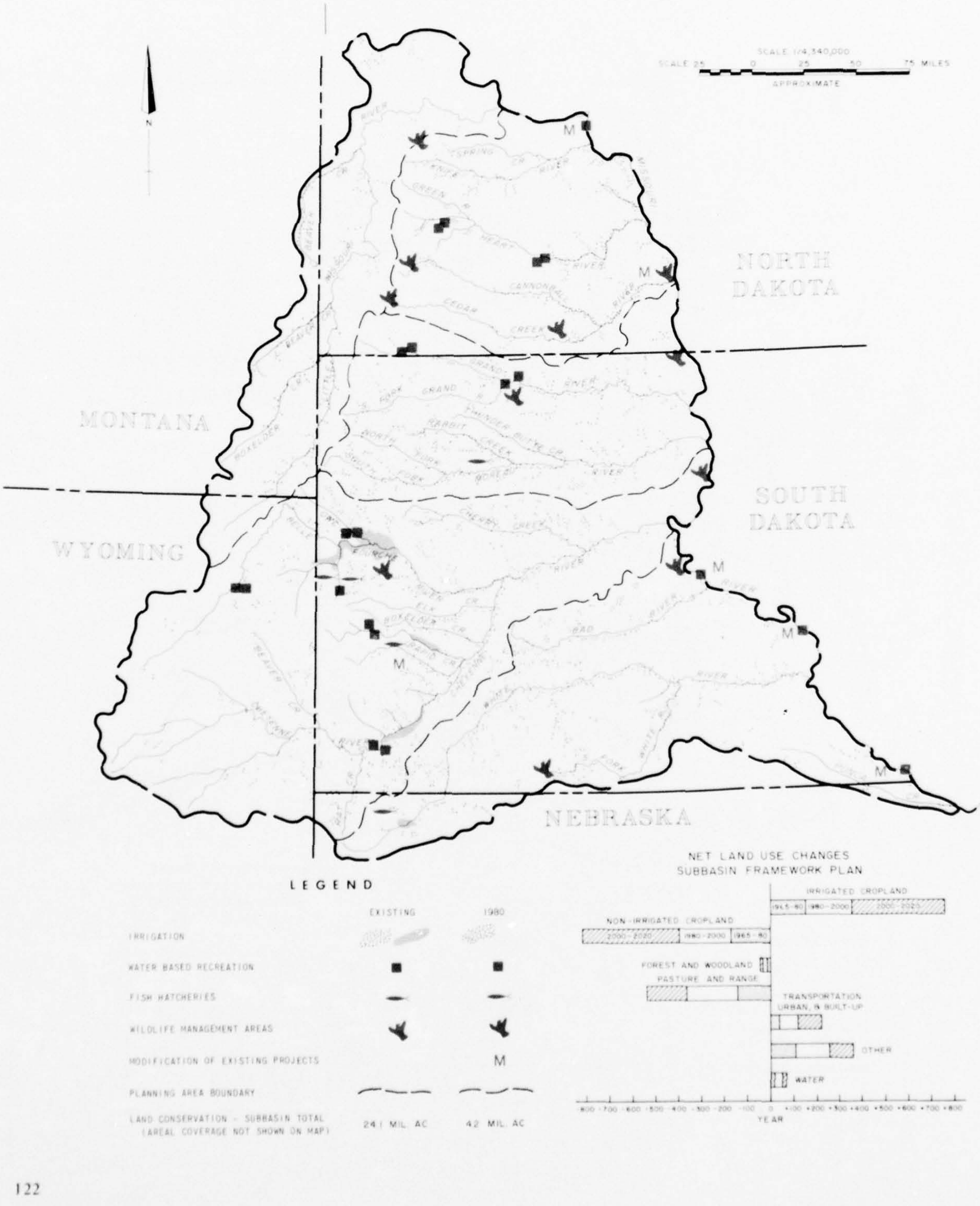


FIGURE 30

WESTERN DAKOTA SUBBASIN

RELATED LAND DEVELOPMENT FEATURES

EXISTING AND 1980 FRAMEWORK PLAN



million would be netted to $464.1 million by grant and assistance programs ($271.3 million) of the Federal Government. On the basis of initial investments, the Federal – non-Federal cost-sharing for the total framework plan would approximate 60 percent Federal and 40 percent non-Federal. On the basis of net costs, however, the cost sharing could approximate 43 percent Federal and 57 percent non-Federal. The distributed costs together with cost-sharing requirements are shown on table 51.

Hatcheries Supplement Natural Fish Reproduction

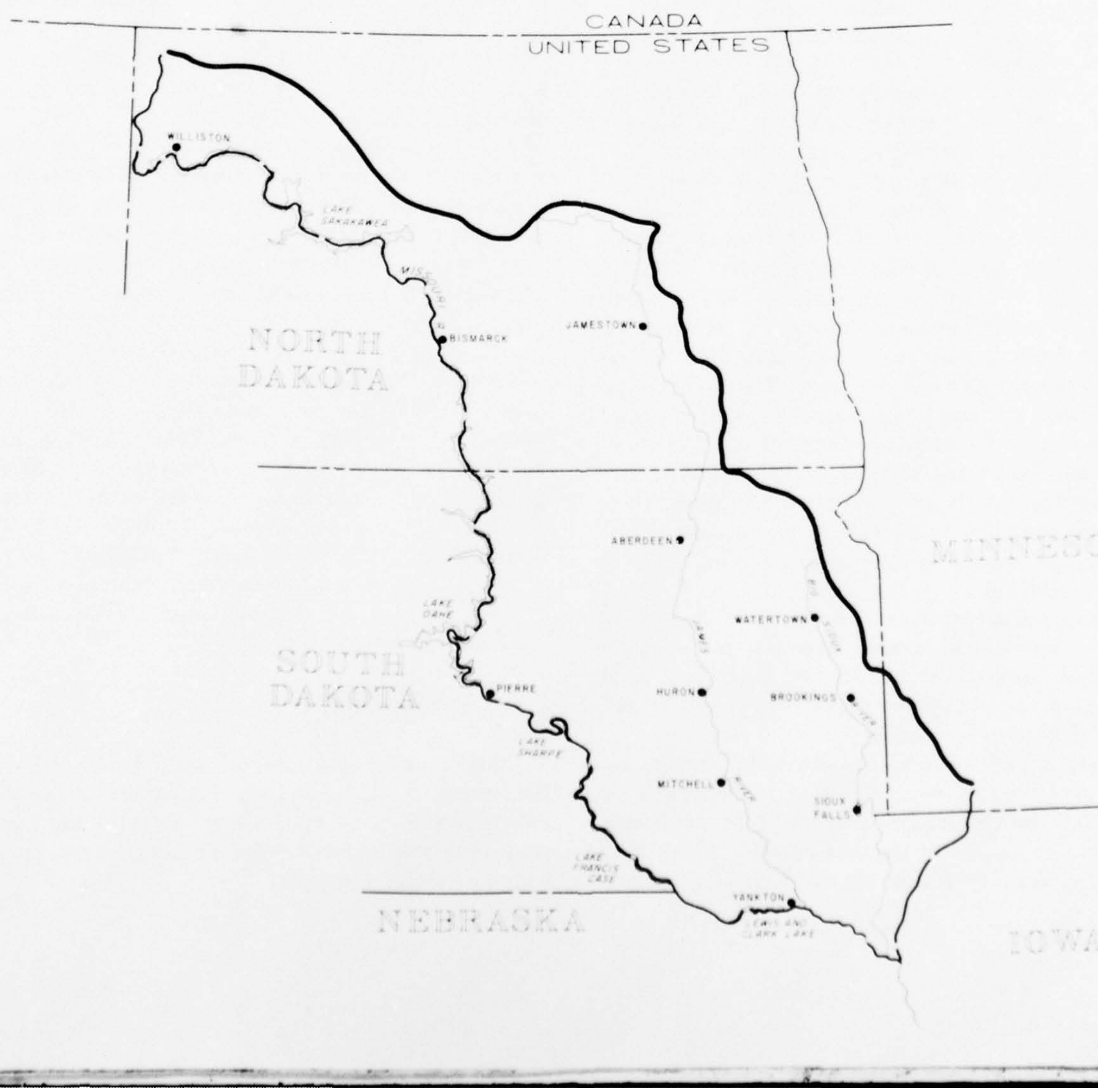
Short-Range Framework Plan

The short-range (1980) features of the subbasin framework plan are summarized in table 52. Figures 29 and 30 show the major features of the 1980 framework plan by geographical location.

EASTERN DAKOTA SUBBASIN

The Eastern Dakota Subbasin, located in the northeastern part of the basin, encompasses an area of about 58,300 square miles. It is primarily an agricultural area devoted to the production of wheat, feed grains, flaxseed, and livestock.

The western third of the subbasin is composed of a rolling to hilly coteau which has numerous short streams along its flanks and large non-contributing areas in its



interior. Physiographically, it is a part of the Great Plains with grazing and the growing of small grains being the major land uses.

To the east of the coteau is a very long, relatively broad lowland drained by the James River. The lowland is flat to gently rolling, and one of the outstanding characteristics of the James River is its extremely flat gradient.

The eastern margin of the subbasin is formed by a second coteau drained by the Big Sioux River. This coteau also has large areas of internal drainage. It is on the subhumid margin of the Corn Belt and the agriculture is based primarily on corn and cattle fattening. This area is the most densely settled and contains most of the urban populations.

Water Resources

The average annual runoff from the major streams in the subbasin ranges from about one-fourth inch for the drainages of the western coteau to about one and one-half inches for the Big Sioux. The major portion of the annual runoff results from spring snowmelt and rains. On the average, about 70 percent of the annual flow occurs from March through June. The flow of subbasin streams is erratic and the volume of water produced varies greatly from year to year. During dry years, the annual flow may average as little as 4 percent of the mean annual volume and during wet years the volume may exceed the average year by 5 times.

The non-contributing areas are liberally dotted with small lakes and potholes. They have little or no streamflow. The runoff collects in the nearest depression and either evaporates or sinks into the ground.

Throughout most of the subbasin there are two general sources of ground water which are differentiated by their depth. One of these is the deep artesian aquifers which extend from under the Great Plains to the west. The artesian pressure in the aquifers is generally great enough to raise the water to or near the ground surface. Production from these ranges from 15 gpm in most areas to more than 500 gpm in a few favored localities. Many rural and municipal water supplies are provided by these aquifers and the supplies are particularly important in the western portion of the subbasin.

The second ground-water source is from the relatively shallow aquifers in glacial deposits or alluvium. Individual aquifers usually do not have large areal extents but the subbasin has a large number of them and they underlie much of its area.

Almost all of the rural domestic water supplies are from ground-water sources but it is impossible to determine the percentages from the deep or shallow aquifers. All but 10 of the municipalities obtain their water supplies from ground water. About 83 percent of the population in the subbasin relies on ground water for domestic and municipal uses.

In recent years, irrigation from shallow ground-water sources has been increasing very rapidly as the aquifers have been explored and identified. Approximately 37 percent of the land under irrigation is served by ground water.

Within the subbasin there were 269 communities in 1965 that had central water systems serving 418,000 people, which is about 62 percent of the 1960 population. Of this number, 221 communities had sewerage systems with 33 plants providing only primary treatment, and 168 having secondary treatment plants. These plants reduced a raw waste load of about 810,000 population equivalents to 101,000 P.E. At present most of the industrial organic wastes are treated by the municipal waste treatment plants. Only 17,000 acre-feet were diverted in 1965 for cooling water for thermal power generation.

Stream waters of the subbasin are very highly mineralized. Stream flows are highly erratic and seasonal flows in many streams are inadequate to handle the discharged treated wastes.

Sioux Falls, S. Dak., provides excellent waste treatment which removes over 97 percent of the BOD and suspended matter from the municipal and industrial wastes before discharge. Even so, at times the natural flow in the Big Sioux River is inadequate to satisfactorily assimilate the effluent without some degradation of surface water quality.

Pollution adversely affects the fisheries in at least five streams totaling about 500 miles, including extensive reaches of the Big Sioux and James river. In addition, at least 11 impoundments totaling some 22,000 acres are similarly affected. Return flows from 119,000 acres of irrigated lands carry agricultural chemicals and other solids back to the streams.

Data are not available to estimate the dissolved solids concentration for all streamflow leaving the subbasin. Analysis of available data shows the average dissolved solids concentration of the James River streamflow near the mouth is about 500 mg/l and the Big Sioux River about 620 mg/l. These analyses indicate a relatively high concentration of dissolved solids in the stream flows from this basin. Most of the dissolved solids are those in the natural runoff as there are return flows from only 119,000 acres of irrigation and moderate amounts of municipal and industrial effluents.

Flood Erosion Control

Existing flood and erosion control projects are summarized in table 53. These improvements are primarily single-purpose in character, although there are some recreation and fish and wildlife values associated with the watershed projects.

Table 53 – EXISTING FLOOD AND EROSION CONTROL PROJECTS
EASTERN DAKOTA SUBBASIN

Type	No.	Levees & Channels	Total Storage	Area Protected	Annual Damages Prevented
		(Miles)	(1,000 AF)	(1,000 AC)	($1,000)
Major Reservoirs					
Missouri River	5		56,100	135	215[1]
Subbasin Streams	1		230	3	93
Upstream Watershed Projects	10			22	268
Flood Retarding	57		35		
Channel Improvement		139			
Grade Stabilization	20				
Levees and Channels	3	44		7	362

[1] Excluding Missouri River damages prevented outside the subbasin.

There are 1,046,000 acres of land subject to flooding in the subbasin with existing projects providing varying degrees of flood protection to 32,000 acres along the tributaries and 135,000 acres along the Missouri River below the main stem dams. The latter value includes the Missouri River flood plain located in the Western Dakota Subbasin. In the unprotected areas, floods usually occur with frequencies of from 1 to 3 years.

In the absence of existing projects, annual flood damages would be about $6,660,000. Existing projects reduce the annual flood damages to $5,721,000 or by 14 percent.

In general, streambank erosion is not a serious problem in the subbasin because of soil characteristics and the relatively flat gradients of the streams, but major erosion problems do exist near the mouths of the Big

Snowmelt Floods In The James River Basin Are Frequent And Prolonged

Sioux, James, and Vermillion rivers. Within the subbasin serious erosion is occurring along 870 bank-miles, or about one percent of the existing channel banks. Average annual losses due to streambank erosion are estimated to be $357,000.

Gully erosion problems occur at various locations throughout the subbasin and are most prevalent in cultivated areas with rolling or rough topography. The equivalent of about 2,500 acres per year are being damaged.

Water Supply

Both ground and surface waters are being used for domestic, industrial, agricultural, and power purposes. Agricultural use of water is principally for irrigation and livestock water.

Irrigation in the subbasin has been increasing rapidly during the past 15 years. There are about 119,000 acres of full-service irrigation. In addition, 112,500 acres are being irrigated intermittently by partial water supplies. Missouri River mainstem reservoirs supply surface water irrigation for 102,300 acres. The 44,300 acres being irrigated from subbasin streams are hampered by low base flows during the late summer months. Groundwater supplies have generally been adequate where they have been developed for irrigation, but the aquifers are scattered. There are suitable soils throughout the subbasin which can be irrigated if adequate subsurface drainage is provided. Physical constraints to irrigation are the fluctuating surface flows and the scattered nature of ground-water aquifers that can sustain large capacity wells, and the suitability of lands to sustain irrigation in the glacial till areas.

Livestock water supplies in the subbasin are adequate to meet current demands except in some areas where, during periods of prolonged droughts, farm ponds may be depleted. About 33 percent of livestock water is supplied from surface water sources and the remainder from ground water sources.

Domestic, industrial, and power supply needs are currently being met throughout the subbasin. Municipal and rural domestic water is being supplied to a population of 418,000 by 269 water systems. The gross water withdrawal is 72,000 acre-feet annually, with 10 of the systems deriving their supply from surface sources, 257 from ground water, and 2 from a combination of these.

The largest gross withdrawals are for the electric power industry. Electrical generating plants include thermoelectric plants, with a total installed capacity of 246 megawatts, and the Oahe hydroelectric plant, with an installed capacity of 595 megawatts. Of the current demand of 3,127 million kwh of electricity, 2,215 million kwh are generated within the subbasin. Stream diversions for thermoelectric plant cooling total about 17,000 acre-feet of water annually, but only 1,000 acre-feet are consumed.

Fish, Wildlife, and Recreation

Developments and facilities for these interrelated functions consist of 902,000 acres of impoundments of which 212,000 acres provide sport fishing; 787,000 acres of land for general recreation; 1,500 miles of classified fishing streams; 36 million acres for wildlife, with 1.2 million acres dedicated primarily to wildlife production; and about 37,000 acres of land and 23,000 acres of water dedicated primarily to general recreation use.

Reservoirs Provide Resting Areas for Waterfowl

The estimated capacity of the fishing resource is 6.2 million fisherman-days with current use approximating 1.5 million fisherman-days. Local areas of fishing shortage exist despite the large overall excess of fishing capacity in the subbasin. The Missouri River mainstem reservoirs provide the major portion of the excess fishing capacity, and because of their large size and distance from population centers, utilization of a great portion of the capacity is difficult to attain.

Hunting capacity is estimated to be about 3.2 million hunter-days with current use about 1.6 million hunter-days. At the present time, wildlife resources are capable of meeting demands for quality hunting except for a few species.

The subbasin is one of the more important waterfowl areas of the Nation with an annual production of over 1.6 million ducks. Preservation of the many lakes, ponds, and marshes in the subbasin is a necessity if waterfowl populations are to be maintained.

Demands for general recreation are currently estimated to be about 10 million recreation days divided about equally between subbasin residents and non-residents. Quality recreation development is limited. Development of recreation facilities in the vicinity of

Sioux Falls, S. Dak., near major transcontinental highways and around natural lakes and the smaller reservoirs, is the greatest current need.

Camping Is A Favorite Activity

Land Conservation and Drainage

Currently, 21 million acres of the privately owned lands in the subbasin are used for crop production, 12.5 million acres are used for pasture and range, 211 thousand acres are in forest and woodlands, 594 thousand acres are in other agricultural uses and 1.8 million acres are in nonagricultural uses. About 119 thousand acres of cropland are irrigated annually. An additional 113 thousand acres of land receive intermitten applications of irrigation water. About 39 thousand acres of Federal land are used for agricultural purposes; six thousand are grazed and 33 thousand produce forest products. An additional 173 thousand acres of Federal land are used for nonagricultural purposes.

Of the 21 million acres used for cropland, 19.9 million acres, or 94 percent, are suitable for sustained cultivation with proper management and conservation measures. The remaining 1.1 million acres of cropland are not suitable for continuous cultivation without sustaining damage to the soil resources. Conversely, about 2.7 million acres of pasture and range are physically suitable and can be used for sustained crop production with proper management and conservation measures.

Wind and water erosion seriously affect lands in the subbasin. Through their own efforts and with Federal technical assistance and cost-sharing available to them, the owners and operators have installed adequate conservation treatment and management on 14.7 million acres of the private agricultural lands. Management-type practices on 13.5 million acres and mechanical or vegetative-type practices on 8.1 million acres are needed to provide adequate levels of conservation treatment and management.

On federally owned lands, 80 percent, or 169 thousand acres are currently adequately treated and managed. The remaining 43 thousand acres in the subbasin need improved conservation treatment and management for sustained use without deterioration.

There are approximately 3.4 million acres of agricultural land in the subbasin subject to excess water problems. Currently, 742 thousand acres of cropland have been provided with adequate drainage. Of the remaining 2.7 million acres subject to excess water, 947 thousand acres are considered potentially suitable and feasible to drain. About 56 percent of this area is currently cultivated and current use would be improved by allowing timely operations. An additional 411 thousand acres of pasture and range and 11 thousand acres of forest and woodland are subject to problems of excess water and are suitable for conversion to cultivated uses. About 501,000 acres will require project type measures to remove excess water.

About 1.7 million acres, or 50 percent of the land with excess water problems are considered infeasible to drain. Of this total, 326 thousand acres are currently used for cropland and should be converted to non-crop uses. This and the remainder should be used for grazing and woodlands and managed to utilize its natural value as wildlife habitat.

Planning Objectives

The economy of the subbasin is predominantly agriculture oriented, with over 92 percent of the land being in private ownership and used for agricultural production. There are wide variations in agricultural production due to drought, flood, hail, and wind. A lack of stability in the agricultural industry is further reflected in an instability in other sectors of the economy which are largely dependent on agriculture. Nearly one-third of the subbasin employment is in agriculture and one-half is in the services sector. Tourism is a growing industry in the subbasin, but it also is faced with income variations because of seasonal characteristics. The principal planning objectives in this subbasin are generally similar to those of the Western Dakotas, except that mineral resources are of no special significance in the Eastern Dakotas. Agricultural intensification and environmental enhancement thus are the prime goals.

The local surface water supplies of the subbasin are not sufficient to permit extensive development. However, the proximity of a major water supply in the Missouri River reservoirs to the west and the favorable topographic characteristics make it possible to divert

Missouri River water for use in the tributary areas, primarily the James River drainage and the Souris-Red River drainages, the latter located outside of the Missouri River Basin. Average pump lifts of only 31 feet at Garrison Dam and 125 feet at Oahe Dam are required to divert water from the Missouri River to these areas.

Since there are three authorized projects in the subbasin, Garrison Unit, Oahe Unit, and Pipestem Dam and Reservoir, these form the nucleus of a framework plan for resource development in the James River drainage (covering about 36 percent of the subbasin area). The Garrison Unit would provide ultimately for the irrigation of 1,007,000 acres of land (with 233,000 acres in the Missouri River Basin); municipal and industrial water for 41 cities and towns; the development of 62 acres for fish and wildlife purposes; and recreation facilities at 9 water impoundments. The initial stage of this project is under construction and will provide for irrigation of 250,000 acres, of which 59,000 acres are in the basin. The project was started in 1967 and completion will extend beyond the 1980 time frame. Future stages for completion of the project are programmed to the 2020 time frame.

The Oahe Unit, located in east-central South Dakota, provides for diversion of Missouri River water for irrigation of 495,000 acres of land; municipal and industrial water supplies for 23 cities and towns; fish and wildlife development at 28 locations; and recreation facilities at four impoundments in the conveyance system. The Unit was authorized for construction in 1968 with initial construction to serve 190,000 acres anticipated in the early 1970's.

The Pipestem Dam and Reservoir, authorized in 1965 and currently in the advance design stage, would be principally a flood control structure. Together with the existing Jamestown Reservoir it would provide a reasonably high level of flood protection to Jamestown, N. Dak.

Other planning areas in the subbasin include the Vermillion River area, Big Sioux River area, and the remaining minor tributaries to the Missouri River. The Vermillion River area, which has about 4 percent of the subbasin's area, is agriculturally oriented, has no urban centers of consequence and its needs are also those of agriculture – intensification and better efficiency in use of the agricultural base. The Big Sioux drainage, which lies adjacent to the Vermillion, has the highest runoff rate in the subbasin, and consequently, flood and erosion problems are more severe than in the rest of the subbasin. It also includes the metropolitan area of Sioux Falls, S. Dak., in the upper part of the drainage and a portion of Sioux City, Ia., at the mouth of the river. Objectives in this area are aimed at water supply, flood abatement, and erosion control. Water quality problems are also significant. In the minor tributary areas water resource development opportunities for small streams are limited. Major opportunities here are a preservation program of wetland development for wildlife propagation, the development of recreation opportunities along the main stem reservoirs on the Missouri River, and better efficiency of the agricultural base through use of Missouri River water.

The subbasin framework was formulated to meet the principal goals of agricultural intensification and environmental enhancement. The types of improvements required were determined on the basis of the characteristics of the individual planning areas and a recognition of actions already taken with respect to water and land development.

Specified Non-Federal Programs and Modifications of Existing Developments

Private irrigation from ground water is expected to increase significantly over the projection period, reaching 442,000 acres by 2020. A similar amount of land would be required to be developed for recreational uses by the State, local, and private sectors if projected needs are to be met. Land conservation programs are anticipated to continue as they have in the historic past. There are no irrigation systems that could be improved, or existing dams that require modification. Additional recreational access, refuge modifications, and requirements for a national recreation area on the Missouri River in this as well as the Western Dakota Subbasin are other enhancement opportunities of existing resource developments. Table 54 summarizes the physical features of the specified non-Federal programs and modifications of existing developments included as a part of the subbasin framework plan.

Water Control and Related Land Development

Water and related land development features of the subbasin framework were formulated in accordance with the planning objectives and those special conditions previously outlined. Consideration of alternatives is limited because of these conditions that water facilities must operate in the context of a total river system. Thus the planning objectives for the subbasin can be met only through the formulation of a water system wherein all elements within the system are dependent on each other for proper operation. Table 55 presents the physical features of the water and related land development component of the subbasin framework plan.

The surface water control features for the total framework plan include 128 multiple-purpose reservoirs providing a total storage of 2,704,000 acre-feet. Of this amount of storage, 2,325,000 acre-feet would be developed in 20 reservoirs having individual storage capacities of greater than 25,000 acre-feet, with the remaining

Table 54 – SPECIFIED NON-FEDERAL PROGRAMS AND MODIFICATIONS OF EXISTING DEVELOPMENTS, FRAMEWORK PLAN – EASTERN DAKOTA SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SPECIFIED NON-FEDERAL PROGRAMS				
Private Ground-water Irrigation	1,000 AC	90	225	442
State, Local, and Private Recreation	1,000 AC	168	298	456
Private Land Conservation	1,000 AC	3,543	10,763	15,100
MODIFICATIONS OF EXISTING DEVELOPMENTS				
Fishing & Recreation Access	Number	108	142	142
National Recreation Area	1,000 AC	18	36	36
Refuge Additions	Number	7	7	7

Table 55 – WATER CONTROL AND RELATED LAND DEVELOPMENT, FRAMEWORK PLAN EASTERN DAKOTA SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SURFACE WATER CONTROL				
Storage	1,000 AF	1,762	2,516	3,031
Local Protection	Miles	524	712	862
Bank Stabilization	Miles	3	9	12
Grade Stabilization	Structures	427	896	1,246
LAND DEVELOPMENT				
Recreation, Fish and Wildlife	1,000 AC	122	181	236
Group Drainage	1,000 AC	6	118	118
Surface Water Irrigation				
Federal	1,000 AC	73	357	918
Non-Federal	1,000 AC	66	169	367
Public Land Conservation	1,000 AC	2	12	18

storage of 379,000 acre-feet developed in 108 reservoirs with individual storage capacities of less than 25,000 acre-feet. In addition to the multiple-purpose storage, 327,000 acre-feet of single-purpose storage would be provided. About 220,000 acre-feet in numerous small impoundments would be provided for general recreation purposes, while 107,000 acre-feet would be similarly developed for fish and wildlife purposes

Of the 2,704,000 acre-feet in multiple-purpose impoundments, 567,000 acre-feet would be inactive storage, 810,000 acre-feet would be for joint beneficial uses, and 1,327,00 acre-feet would be for flood control. The joint use storage would be used as follows:

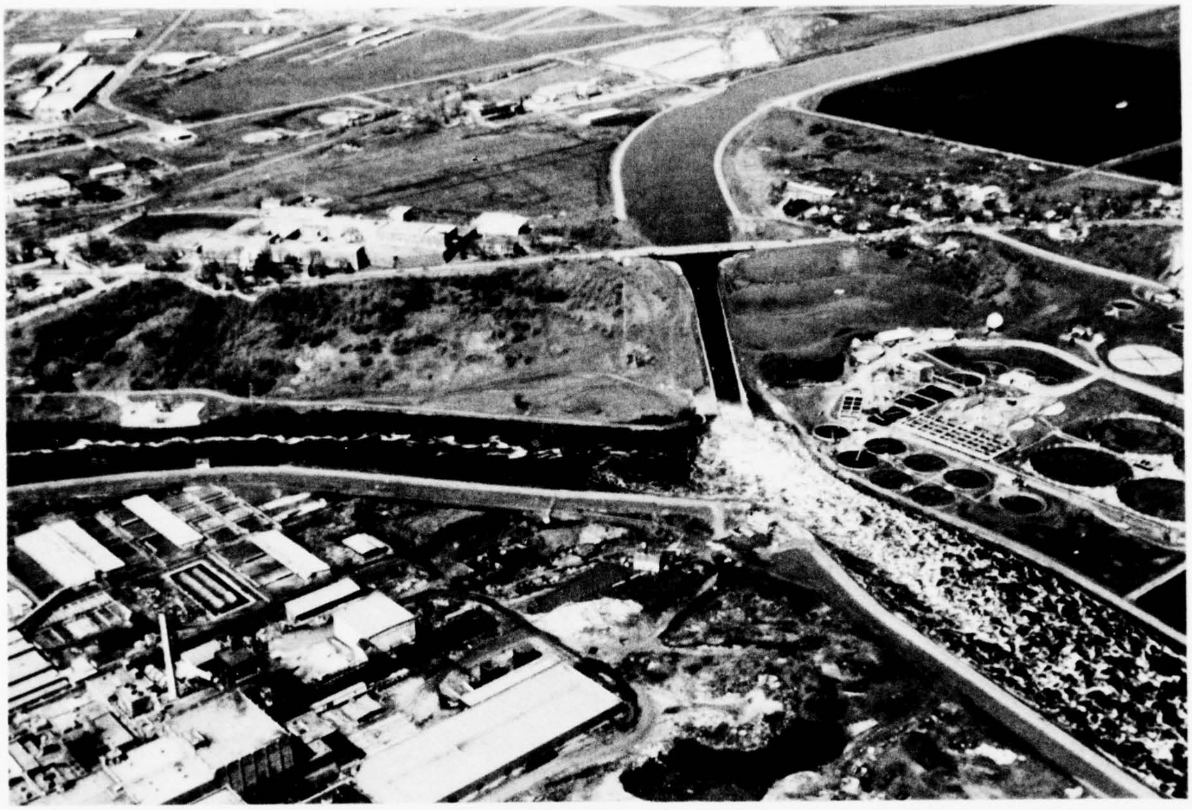
Streamflow Augmentation, Quality	707,000 acre-feet
Irrigation	705,000 "
Municipal & Industrial	73,000 "
Recreation, Fish & Wildlife	404,000 "
Flood Control	Incidental benefits from regulation

Channel and levee improvements covering 14 stream miles would be provided for local flood protection at the communities of Madison and Davis in South Dakota and Sioux City, Iowa, and 245 miles along major streams for protection of agricultural lands. The remaining 603 miles would be associated with watershed improvements. Other instream controls would consist of 12 miles of bank stabilization measures located primarily on the James River and 1,246 grade stabilization structures to prevent gully erosion. Most of the grade control structures would be in the Big Sioux drainage.

Related land development features would include about 236,000 acres of land, mostly associated with reservoirs, for recreation and fish and wildlife purposes; group system drainage measures for 118,000 acres of agricultural lands; and the surface irrigation of almost 1.3 million acres of land, including Indian projects. Approximately 743,000 acres of this irrigation would be accomplished by the Garrison and Oahe Irrigation Units by diversion of Missouri River water. Land conservation practices in a nominal amount of 18,000 acres of federally owned lands would also be applied.

Environmental Enhancement and Non-Structural Measures

Environmental enhancements, an integral part of the subbasin framework plan, are in support of the planning



Projects Such As This At Sioux Falls, South Dakota, Provide Flood Protection For Urban Areas

Irrigation Helps Stabilize Agricultural Production

objectives and generally reflect the same considerations previously outlined for the other subbasins. In this subbasin, however, the acquisition, preservation, and management of about 1.1 million acres of wetlands for waterfowl and other purposes comprise a significant plan feature not duplicated in any of the other subbasins. Non-structural considerations are limited to flood plain management since there are no opportunities for forestry or precipitation management in this subbasin. Table 56 summarizes the physical features of this element of the subbasin framework plan.

Land and Water Changes

Net land use changes that would be required by the subbasin framework plan are presented in table 57. These changes reflect the same considerations previously outlined for other subbasins. However, amplification of one feature of the subbasin framework plan and its affects on land use are not obvious from table 57. The preservation of about 1.1 million acres of wetlands reflects an acquisition and management feature on lands in the current agricultural inventory. The current pasture and range acreage approximates 12.5 million acres which includes wetlands. Within the context of the plan, the wetland areas are currently considered as essentially

Table 56 – ENVIRONMENTAL ENHANCEMENT AND NON-STRUCTURAL MEASURES
FRAMEWORK PLAN – EASTERN DAKOTA SUBBASIN

Feature	Unit	Amounts 1980	2000	2020
		(Cumulative Above Current)		
ENVIRONMENTAL				
Sewage Treatment Plants[1]	Number	275	300	400
Water Supply & Treatment	1,000 AF/YR	49	90	136
Fish and Wildlife				
Wetlands	1,000 AC	1,124	1,124	1,124
Management Areas	1,000 AC	23	23	23
Fish Impoundments	Number	36	71	106
Special Areas	Number	2	4	4
Trails	Miles	390	620	620
NON-STRUCTURAL				
Flood Plain Management				
Area	1,000 AC	51	234	329
Flood Hazard Reports	Number	9	29	46

[1] Includes existing plants.

Table 57 – LAND USE CHANGES, FRAMEWORK PLAN – EASTERN DAKOTA SUBBASIN

Principal Use	Net Land Use Changes 1965-1980	1980-2000	2000-2020	1965-2020
	(Thousand Acres)			
Irrigated Cropland	+228	+521	+974	+1,723
Non-irrigated Cropland	-380	-407	-922	-1,709
Forest and Woodland	- 10	- 22	- 57	- 89
Pasture and Range	-371	-375	-540	-1,286
Transportation, Urban, & Built-up	+ 63	+110	+159	+ 332
Other (Rec., F&WL, & Other Uses)	+377	+158	+365	+ 900
Water	+ 93	+ 15	+ 21	+ 129

nonproductive areas for agricultural production and in the future will be managed for waterfowl and related purposes.

Water supply studies, similar to those made for the preceding subbasins, indicate a net streamflow depletion of 4,413,000 acre-feet by the year 2020. Of this amount, 2 million acre-feet reflect an export of water to the Souris and Red rivers for the Garrison Unit.

Ground-water developments included in the subbasin framework plan are limited to irrigation, municipal and rural domestic, and livestock uses. Depletions of ground-water supplies would be at rates generally similar to those described for the Western Dakota Subbasin.

Table 58 presents a summary of water withdrawals for various uses and the resulting depletion of streamflow and ground water.

Table 58 – WATER WITHDRAWALS, DEPLETIONS, AND OTHER CHANGES
FRAMEWORK PLAN – EASTERN DAKOTA SUBBASIN

Service	Withdrawals Ground 1980	2000	2020	Surface 1980	2000	2020	Depletions Ground 1980	2000	2020	Surface 1980	2000	2020
	(Cumulative Above Current – Thousand Acre-feet/Year)											
Irrigation	89	238	476	327	1,023	2,503	49	102	212	225	803	1,911
M&I, Rural Domestic	10	23	41	39	67	95	1	2	4	9	16	24
Thermal Power				182	415	684				5	16	36
Livestock	6	13	52	18	40	40				24	53	92
Land Conservation				10	33	71				10	33	71
Wetlands, Fish and Wildlife				61	64	149				61	64	149
Evaporation				91	114	130				91	114	130
Exports				411	1,087	2,000				411	1,087	2,000
Total	105	274	569	1,139	2,843	5,672	50	104	216	836	2,186	4,413

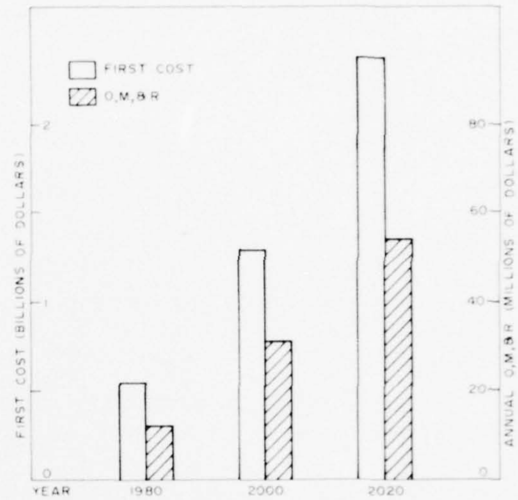
Costs

Estimates of first costs and annual operation, maintenance, and replacement costs for all features of the subbasin framework plan were made. The total first cost of about \$2.4 billion, as shown in figure 31, reflects new investment requirements. Within the framework plan, the implementation of the Garrison Diversion Unit features is shown throughout the projection period. However, since the initial stage of this Unit is currently under construction, the cost to complete the first stage (\$247 million of which \$60 million is allocated to the Missouri Basin), is not included as a future new funding requirement. Figure 31 illustrates the new investment requirements for implementation of the subbasin framework plan.

First costs, as shown in figure 31, were distributed to each functional item included in the subbasin framework plan. As shown in figure 32, the largest share of the total investment would be for irrigation (\$877 million, or 37 percent), land conservation (\$475 million, or 20 percent), recreation (\$365 million, or 15 percent), and water supply and treatment (\$177 million, or 7 percent).

Costs were also disaggregated to reflect the cost-sharing relationships between Federal and non-Federal requirements. On the basis of existing legal and policy consideration, initial Federal investments of \$1,133.2 million would be required. Of this amount, \$774.8 million would have to be repaid by non-Federal interests as well as provide for \$40.6 million for initial cost-sharing, resulting in a net Federal investment of \$358.4 million. Similarly, non-Federal programs with a total first cost of \$1,209.9 million would be netted through Federal grant and assistance programs (\$448.1 million) to \$761.8 million. On the basis of initial investments, cost-sharing would be on the order of 66 percent Federal and 34 percent non-Federal. If net costs are used, this relationship would be 34 percent Federal and 66 percent non-Federal. The cost-sharing analyses are summarized in table 59.

FIGURE 31
ESTIMATED FIRST COSTS AND
ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENTS
FRAMEWORK PLAN
EASTERN DAKOTA SUBBASIN
(cumulative above current)



Short-Range Framework Plan

The short-range (1980) features of the subbasin framework plan are presented in table 60, while location of major features of the plan are shown on figures 33 and 34.

FIGURE 32
DISTRIBUTION OF COSTS BY FUNCTIONAL PURPOSES
FRAMEWORK PLAN
EASTERN DAKOTA SUBBASIN

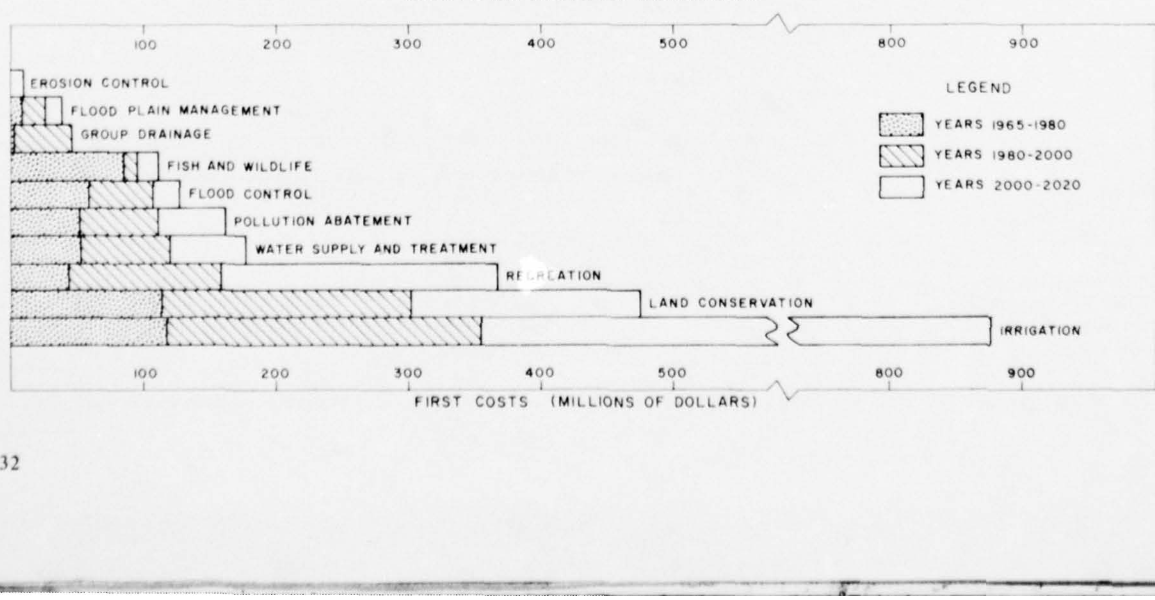


Table 59 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY — EASTERN DAKOTA SUBBASIN

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						68.9		68.9
State & Local Recreation						218.1	87.3	130.8
National Recreation Area	26.3	26.3						
Private Land Conservation						475.0	237.5	237.5
Irrigation Rehabilitation								
Access						.2		.2
Refuges	4.3	4.3						
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	49.5	39.6			9.9			
Other Single Purpose Res.	14.1	14.1				14.1		14.1
Grade Stabilization	8.4	6.8			1.6			
Bank Stabilization	.6	.3			.3			
M. P. Reservoirs	223.0	(162.6)	(60.4)	(65.6)				
Assoc. Joint Works 1/	569.0		569.0	549.9				
Water Quality			18.8					
Irrigation			554.7	554.7				
M & I			18.8	18.8				
Power								
Recreation		84.0	14.9	42.0				
Fish and Wildlife			20.8					
Flood Control		78.6	1.4					
Surface Water Irrigation	159.3	159.3		159.3		94.2		94.2
Group Drainage	45.5	22.8			22.7			
Public Land Conservation	.3	.3						
Environ. and Non-Structural								
Sewage Treatment						138.0	41.4	96.6
Water Supply & Treatment						158.0	79.0	79.0
Fish and Wildlife								
Wetlands	55.6	52.8			2.8			
Management Areas						5.8	2.9	2.9
Fish Hatcheries								
Fish Impoundments	6.6	3.3			3.3			
Scenic Rivers								
Trails	10.5	10.5						
Flood Plain Management	.8	.8				37.6		37.6
Forest Management								
Precip. Management								
Totals	1,173.8	503.8	629.4	774.8	40.6	1,209.9	448.1	761.8

1965-2020 Total: 2,383.7

1/ These include primarily the pumping plants, canals, and re-regulating reservoirs of the Garrison and Oahe Units.

Table 60 – FRAMEWORK PLAN FOR 1980 – EASTERN DAKOTA SUBBASIN

Plan Feature	Description and Purpose	Initial First Costs			Annual Operation, Maintenance and Replacement Costs		
		Federal	Non-Fed	Total	Federal	Non-Fed	Total
		(Million Dollars)			(Thousand Dollars)		
Storage Reservoirs							
Single-purpose Impoundments	Fish and wildlife reservoirs with 137,000 acre-feet of storage.	6.9	1.3	8.2	0	99	99
Multi-purpose Impoundments, Major and Minor	Seven impoundments having 1,444,000 acre-feet of storage and 41 minor reservoirs with a capacity of 181,000 acre-feet for water quality, irrigation, M&I, recreation, fish and wildlife, and flood control.	77.0	0	77.0	249	1,181	1,430
Associated Joint Works	Pumping plants, canals, reregulating works of Garrison and Oahe Units.	70.0	0	70.0			
Irrigation							
New Systems	Provide 229,000 acres of irrigation subbasin-wide.	5.7	32.6	38.3	0	3,123	3,123
Group Drainage	Provide 6,000 acres of public or group drainage.	0.7	0.7	1.4	0	14	14
Local Flood Protection	Channel and levee improvements involving 524 miles for protection of Pukwana, Madison, and Davis, S. Dak. and Sioux City, Ia., agricultural lands, and both urban and agricultural areas associated with watershed improvements.	35.6	8.9	44.5	0	172	172
Grade Stabilization	427 grade stabilization structures for erosion control.	3.7	.9	4.6	0	23	23
Bank Stabilization	Bank protection on the James River covering 3 miles.	0.1	0.1	0.2	0	2	2
Recreation	The development of 18,000 acres for a national recreation area along the main stem reservoirs and 168,000 acres by the State, local, and private sector, providing 108 new access sites to existing water, and 390 miles of trails (NRA).	19.3	1.8	21.1	190	240	430
Fish and Wildlife	23,000 acres for game management, 1,124,000 acres of wetlands, 27,000 additional acres for 7 existing refuges, and 36 new fish impoundments.	62.3	8.0	70.3	136	67	203
Water Supply and Treatment	Treatment facilities to serve 142,000 people and development of individual supplies.	23.5	23.5	47.0	0	912	912
Sewage Treatment	Enlargement of 168 secondary facilities, additions to 33 secondary facilities, and construction of 74 new secondary facilities.	12.6	29.4	42.0	0	1,592	1,592
Land Conservation	Land treatment measures for 3,543,000 acres of private land and 2,000 acres of federally owned land.	57.6	57.5	115.1	1	4,000	4,001
Flood Plain Management	Preparation of 9 flood hazard reports covering 51,000 acres of flood plains.	0.2	9.2	9.4	4	46	50
Total		375.2	173.9	549.1	580	11,471	12,051

FIGURE 33

EASTERN DAKOTA SUBBASIN

PRINCIPAL WATER CONTROL FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

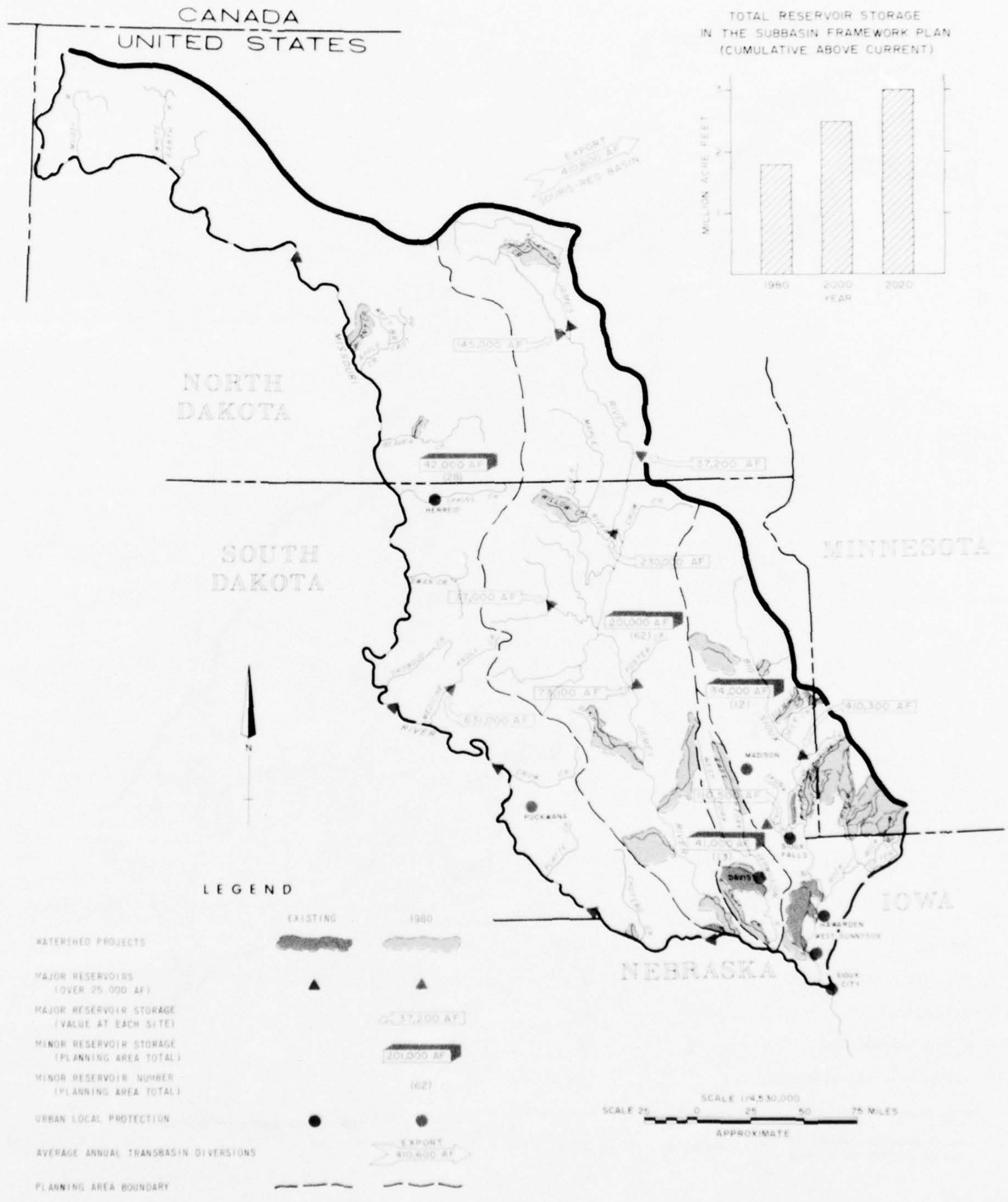
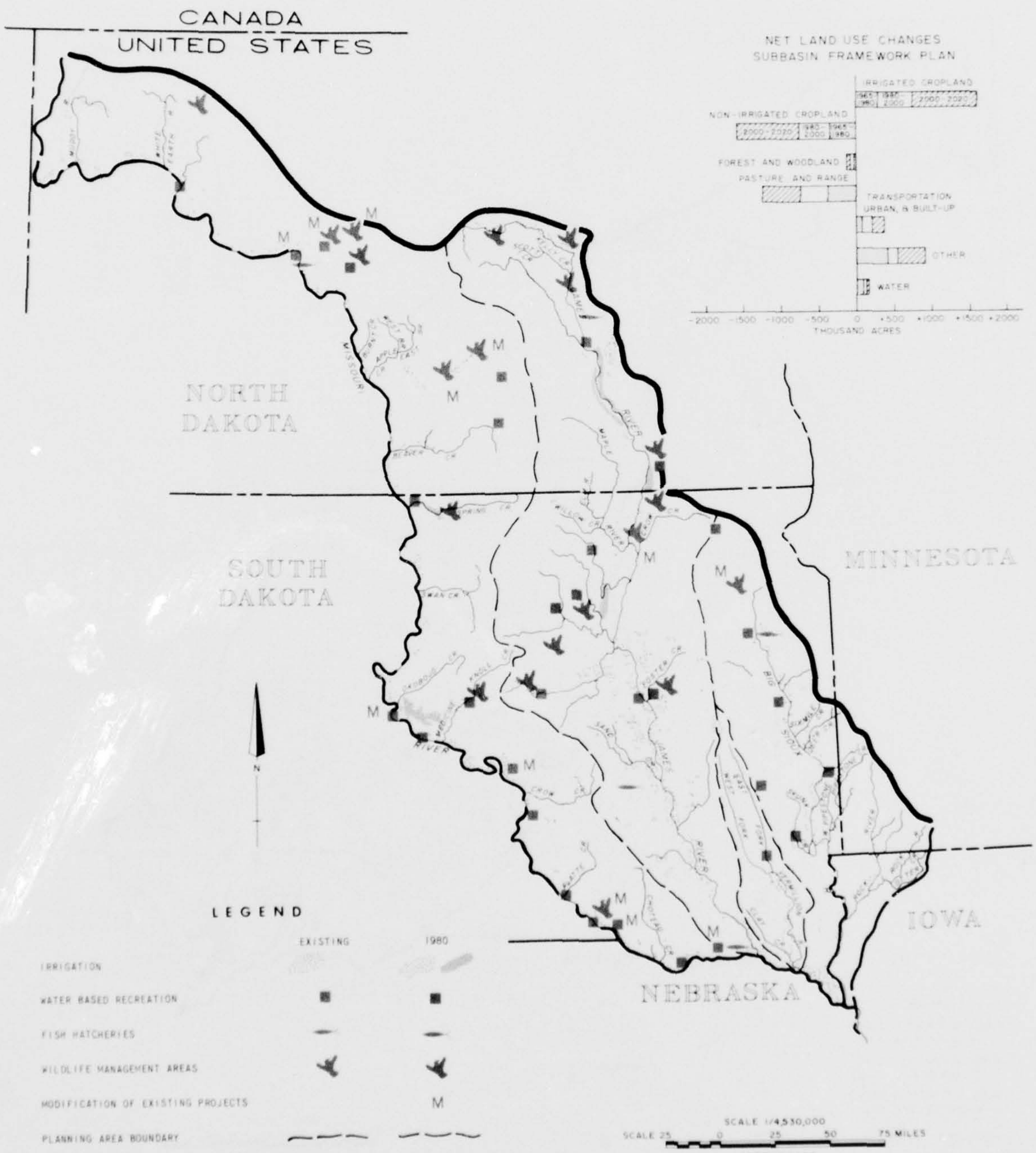


FIGURE 34

EASTERN DAKOTA SUBBASIN

RELATED LAND DEVELOPMENT FEATURES

EXISTING AND 1980 FRAMEWORK PLAN



Wetlands Preservation Is Important In This Subbasin

PLATTE-NIOBRARA SUBBASIN

The Platte-Niobrara Subbasin, the largest delineated within the Missouri Basin, includes an area of about 99,500 square miles. It contains the metropolitan centers of Denver, Colo., in the west and Lincoln, Nebr., in the east.

Water Resources

Average annual runoff ranges from over 20 inches in the Colorado Rockies to 0.5 inches through the plains, and then up to about 4 inches in eastern Nebraska. However, the historical streamflow of the Platte River near its mouth reflects an average runoff of less than one inch per year. This is a result of relatively low average annual runoff from the North and South Platte drainages and depletions due to evaporation losses from storage reservoirs, streamflow depletions for irrigation, and withdrawals and uses for other purposes. In addition to in-basin water supplies, 407,000 acre-feet are imported from the west slope to the South and North Platte rivers in accordance with existing decrees. The streamflow of the Niobrara River near the mouth has averaged nearly 2 inches per year. This is caused by a relatively steady ground-water contribution from the sandhills of northwest Nebraska.

Ground water is used extensively for municipal, industrial, rural domestic, and irrigation purposes. There is a large aquifer underlying most of Nebraska which generally yields water at a rate of over 500 gallons per minute. However, in some local areas withdrawals are great enough to cause a water level decline ranging from 10 to 50 feet.

Within the subbasin there were 340 communities with central water supply systems, serving 1.9 million people

which is about 95 percent of the 1960 population. Only 242 had public sewerage systems, and of this total number, 52 communities provided only primary treatment and 168 had secondary treatment plants. On this basis and in considering the industrial waste loads as well, they reduced the total pollution load from 7.6 million to about 4.4 million population equivalents. Large quantities of separate industrial wastes are not adequately treated.

In addition to the municipal waste discharges, wastes from cattle feedlots, canneries, meat packing plants, and food processing (including beet-sugar mills) contribute additional pollution loads to the receiving streams. Severe bacterial pollution exists below major waste discharges.

Return flows from 2,986,000 irrigated acres add to the quality problems of the streams, but irrigation diversions from streams with large amounts of municipal and industrial waste also assist in reducing the magnitude of the organic pollution problem in the subbasin.

The dissolved solids concentration in the streamflow leaving the subbasin averages about 400 mg/l. This might indicate the subbasin has no serious dissolved solids concentration problems from almost 800,000 acre-feet of municipal, mining, and industrial effluents and the return flows from 2,986,000 acres of irrigation. Available data show the average dissolved solids concentration of the South Platte River at Julesburg, Colo., (Colorado-Nebraska state line) is about 1,500 mg/l and the North Platte River at Lisco, Nebr., (above McConaughy Reservoir) is about 500 mg/l. The dissolved solids concentration of both streams at these locations is influenced by the return flow of water used for irrigation, municipal water supply, mining, and by industry. Inflows of good quality water between these points and the mouth of the Platte River reduce the dissolved solids concentration to about 400 mg/l, even though there are additional municipal, industrial, and irrigation uses.

Flood and Erosion Control

Existing flood and erosion control projects are summarized in table 61.

Table 61 – EXISTING FLOOD AND EROSION CONTROL PROJECTS
PLATTE-NIOBRARA SUBBASIN

Type	No.	Levees & Channels	Total Storage	Area Protected	Annual Damages Prevented
		(Miles)	(1,000 AF)	(1,000 AC)	($1,000)
Major Reservoirs	8		3,420	128	6,275
Upstream Watershed Projects	25			90	1,554
Flood Retarding	211		80		
Channel Improvement		169			
Grade Stabilization	83				
Levees and Channels	8	42		4	314
Bank Protection		1			8

In the absence of these projects, average annual flood losses would be about $24.8 million under current conditions. Existing projects reduce these losses to about $15.7 million, a 37 percent reduction.

The most significant flood problem area is at Denver, Colo., where several small streams converge on the metropolitan area and where considerable flood plain development exists. Significant flood problems exist also within the Lower Platte and Elkhorn river drainages. Flood damages are moderate along the North Platte River because of existing reservoir control and along the Loup River because of low flood runoff from the sandhills area. The Niobrara River causes relatively low flood damages because of the high infiltration rate in the sandhills and limited floodplain development.

Aftermath Of The 1965 South Platte River Flood At Denver

Streambank erosion is a continuing problem along most of the main streams and many of the tributary reaches with 1,520 bank-miles, or one percent of the existing channel banks, receiving serious erosion. Average annual losses due to streambank erosion are estimated to be $520,000. Only a few extensive bank stabilization projects have been constructed, such as at Gering Valley in western Nebraska, but numerous emergency-type measures have been installed by local interests at bridges and other structures. These consist primarily of car bodies or rock protection.

Gully erosion and channel degradation account for a large share of the land damage in the tributary areas. It is estimated that 1,940 acres are damaged each year by gullies. Assuming the rate continues with little or no recovery, over 97,000 acres of land would be damaged in a 50-year period with an estimated annual loss of $557,000.

Water Supply

Both ground and surface water are being withdrawn for domestic, industrial, agricultural, and power uses. Agricultural purposes include both irrigation and livestock water. About 2,986,000 acres were being irrigated in the early 1960's. The amount of water delivered to the farm for this purpose is about 5.7 million acre-feet annually.

Livestock water supplies are adequate to meet current demands except in some areas where, during prolonged droughts, farm ponds may be depleted and ground-water levels may decline. Livestock annually consume about 81,000 acre-feet in this subbasin. About 32 percent of the livestock water source is surface and 68 percent is ground water.

Domestic, industrial, and power supply needs are currently being met throughout the subbasin. Table 62 summarizes existing facilities and uses.

Table 62 – EXISTING DOMESTIC, INDUSTRIAL, AND POWER WATER USES PLATTE-NIOBRARA SUBBASIN

System	Population Served	Withdrawals	Depletions
	(Number)	(Acre-feet)	
Municipal & Industrial	1,867,000	493,000	180,000
Rural Domestic	*364,000*	14,000	
Thermal Power		454,000	11,000

One of the largest users of water is the electric power industry. Thermal plants, with an installed capacity of 2,100 megawatts, provide about 80 percent of the total electric generation. Streamflow and ground-water withdrawals for cooling water purposes amount to 454,000 acre-feet, but only 2 percent is consumed.

Fish, Wildlife, and Recreation

Wildlife makes use of over 62 million acres. Of that amount, 220,000 acres are devoted to single-purpose wildlife use. Another 908,000 acres are of primary importance to wildlife, mostly for habitat. Virtually all of the 654,000 acres of water in the subbasin are valuable to fish and wildlife.

The present capacity of wildlife resources to supply quality hunting, 2 million hunter-days per year, is estimated to be essentially equal to the present use.

The current demand for fishing is 6.8 million fisherman-days per year, compared to a total capacity of 10.3 million fisherman-days. However, the actual use amounts to 4.1 million fisherman-days, or 40 percent of capacity, mainly because the surplus capacity is located at reservoirs removed from the heavily populated areas.

Refuges Are Needed To Support And Propagate Wildlife

The total land area used for outdoor recreation is over 8 million acres. Large Federal areas, principally the nine national forests and grasslands and the public domain account for about 90 percent of the total recreation land. A land area of 365,000 acres and a water area of 16,000 acres are dedicated primarily to recreation. The recorded recreation use of facilities in 1965 was 22 million recreation-days.

There are moderate to severe shortages of camping, boating, and water skiing facilities. Areas in and near the major population centers of Denver, Omaha, and Lincoln have the greatest current need for additional recreation facilities.

Land Conservation and Drainage

Currently, 15.6 million acres of the privately owned lands in the subbasin are used for crop production, 35.1 million acres are used for pasture and range, 1.9 million acres are in forest and woodlands, 621 thousand acres are in other agricultural uses, and 1.9 million acres are in non-agricultural uses. About 2.8 million acres of cropland and 202 thousand acres of pasture and range are irrigated annually. An additional 150 thousand acres of land receive intermittent applications of irrigation water. About 7.4 million acres of Federal land are used for agricultural purposes, 6 million are grazed, and 3 million produce forest products. An additional 326 thousand acres of Federal land are used for non-agricultural purposes.

Of the 15.6 million acres used for cropland, 14.0 million acres, or 90 percent, are suitable for sustained cultivation with proper management and conservation measures. The remaining 1.6 million acres of cropland are not suitable for continuous cultivation without sustaining damage to the soil resources. Conversely, about 2.9 million acres of pasture and range are physically suitable and can be used for sustained crop production with proper management and conservation measures.

Wind and water erosion seriously affect lands in the subbasin. Through their own efforts and with Federal technical assistance and cost-sharing available to them, the owners and operators have installed adequate conservation treatment and management on 24.5 million acres of the private agricultural lands. Management-type practices on 20 million acres and mechanical or vegetative-type practices on 10.7 million acres are needed to provide adequate levels of conservation treatment and management.

On federally owned lands, 5.6 million acres, or 72 percent, are currently adequately treated and managed. The remaining 2.2 million acres in the subbasin need improved conservation treatment and management for sustained use without deterioration.

There are approximately 2.5 million acres of agricultural land in the subbasin subject to excess water problems. This total is exclusive of the 450,000 acres of land with an excess water problem caused by irrigation water that is included in irrigation systems. Currently, 465 thousand acres of cropland have been provided with adequate drainage. Of the remaining 2 million acres subject to excess water, 745 thousand acres are considered potentially suitable and feasible to drain. About 22 percent of this area is currently cultivated, and current use would be improved by allowing timely operations. An additional 560 thousand acres of pasture and range and 23 thousand acres of forest and woodland are subject to problems of excess water and are suitable for conversion to cultivated uses. About 548,000 acres will require project-type measures to remove excess water.

About 1.2 million acres, or 50 percent, of the land with excess water problems are considered infeasible to drain. Of this total, 80 thousand acres are currently used for cropland and should be converted to non-crop uses. This and the remainder should be used for grazing and woodlands and managed to utilize its natural value of wildlife habitat.

Planning Objective

The subbasin is composed of four river systems having different characteristics with respect to water supply, climate, and economics. These are the South Platte River (mostly in Colorado); the North Platte River (mostly in Wyoming); the Lower Platte River in Nebraska; and the Niobrara River, a separate drainage from the Platte and located along the northern fringe of Nebraska.

Historic population growth of this subbasin has been greater than any other subbasin within the Missouri River region. This growth has been most pronounced in

the South Platte River drainage dominated by the Denver metropolitan area. Other metropolitan areas with significant growth include Greeley and Fort Collins, Colo., and Cheyenne, Wyo., in the South Platte drainage, Casper, Wyo., in the North Platte drainage, and Grand Island and Lincoln in the Lower Platte drainage of Nebraska. Other urban communities account for about 20 percent of the subbasin's population. It should be noted that no large urban communities are within the Niobrara River drainage.

Because of the varying physical and climatic characteristics that affect water resource planning, objectives of such planning also vary between the drainages outlined. In the South Platte River system all water supplies, natural and imports from the west slope of the Rocky Mountains, have been appropriated for beneficial uses. Such appropriations are in consonance with state law which also defines beneficial uses and priority of uses. The South and North Platte river areas are two in the Missouri River Basin that receive import water, in this case from the Colorado River Basin. The South Platte River area has been and continues to be a critical water-short area.

Within the physical and legal constraints, the principal planning objectives here are to develop water resources to support the economic growth of the Denver metropolitan area, as well as other urban communities; to maintain the irrigated rural economy at about the same level as at present; to provide water supplies to other segments of the rural economy in order to meet future agriculture requirements; to provide a reasonable degree of flood protection to the relatively high valued urban and rural flood plains; and to maintain environmental quality at the highest practicable level. From a planning standpoint, alternative courses of action are limited to exploring means for increasing the available water supply and for apportionment of water to various uses, which, in a large part and aside from financing, will be dictated by legal arrangements.

The situation in the North Platte River system is generally similar to that in the South Platte. North Platte water uses, however, are dominated by agriculture rather than by expanding urban requirements. The same general objectives outlined above, with the difference noted, would apply to the North Platte River basin.

Problems and water resource objectives for the Platte River system in Nebraska are considerably different than those outlined for the South and North Platte river systems. With a vast ground-water aquifer stretching across the State, use of ground water greatly exceeds use of surface supplies for all purposes. Irrigation in Nebraska exceeds that of all other States in the basin, most of which is undertaken by the private sector drawing on ground-water supplies. The Platte and its tributaries lie in a semiarid area at the western end and in a subhumid area to the east. With this situation, high flow or flood conditions are more prevalent and severe in the eastern end. Streamflows are also erratic with substantial periods of extremely low flows. From a water control and use standpoint, high and low-flow control are obvious needs; but, in addition, the relationship of ground water to streamflow is an important consideration currently and as further water resources development is contemplated in this area. Moreover, localized ground-water problems have arisen due to ground-water depletions or from inadequate drainage. One large system for the use of both surface and ground water has been authorized for development to overcome ground-water depletions in central Nebraska.

Since Nebraska is principally an agricultural State, the major planning goal is to intensify and increase agricultural efficiency. Consequently, land conservation, flood control, erosion control, irrigation, and drainage are important elements. The needs of the urban communities also must be met if the total economy is to flourish. From an environmental viewpoint, water quality must be maintained since water is worthless if it cannot be used. Recreation and fish and wildlife enhancements, unlike those in the upper basin areas, are aimed at supplying mostly resident demands and are usually oriented toward the urban communities.

The Niobrara River drainage is sparsely populated and is mainly an agricultural area. Limited use is made of its current water supply and demands in the future will not be too great. The most promising opportunities here are for environmental enhancement and recreational development. The agricultural base can be improved by an extension of irrigation, but this should not conflict significantly with the environmental opportunity.

Specified Non-Federal Programs and Modifications of Existing Developments

The development of irrigation through the use of ground waters by the private sector is expected to continue into the long-term future at varying rates for individual areas within the subbasin. In the South and North Platte river areas, this type of irrigation is anticipated to show nominal increases, reaching 80,000 acres in the South Platte area and 32,000 acres in the North Platte area by the year 2020. In the Lower Platte River area in Nebraska, however, private ground-water development is expected to increase substantially over the projection period, reaching a total of 1,463,000 acres by 2020. Historical experience and the availability of ground waters tend to substantiate this level of development. In the Niobrara River area, modest increase of private ground-water development is anticipated, approximating 157,000 acres by 2020.

Development of recreation by the State, local, and private sectors would be substantial in some parts of the

Ground Water Is Used Extensively For Irrigation In Nebraska

subbasin if all projected recreation needs are to be met. In the South Platte area, primarily in and near the Denver metropolitan area, such development would require 376,000 acres of land and water with its attendant facilities. Development magnitude in the North Platte and Lower Platte areas would be 79,000 acres and 123,000 acres, respectively. Most of the development in the Lower Platte area would be in the eastern part near Lincoln and Omaha. Estimated development in the Niobrara area would be relatively small, with only 24,000 acres involved.

Land conservation practices on private lands are estimated to be applied at a somewhat reduced rate compared to historical application, yet being quite substantial in overall magnitude. Rates of application within the various areas of the subbasin would be generally uniform. Table 63 presents the physical features of the specified non-Federal programs.

Opportunities for meeting future needs in the most economical manner by modifying existing developments are extensive in the subbasin. The efficiency of existing irrigation systems can be materially increased by consolidating 318 miles of ditches, lining 1,850 miles of ditches, and improving the drainage of 337,000 acres.

In order to meet some of the future municipal and industrial needs in the South Platte area, the capacity of the existing Boulder Reservoir on St. Vrain Creek and Gross Reservoir on South Boulder Creek could be increased by 3,000 and 70,000 acre-feet, respectively.

The potential for enhancing general recreation and fishing use can be realized by providing about 450 different access areas to the many existing lakes and reservoirs, especially in the western part of the subbasin. Improvement of two existing refuges and one fish hatchery also would be warranted. Table 64 summarizes pertinent modifications of existing developments, which, together with features shown in table 63, comprise one of the key components of the total subbasin framework plan.

Water Control and Related Land Development

The water control and related land development features of the subbasin framework plan were formulated in response to the objectives and physical characteristics outlined previously for the various planning areas. Reservoir storage systems are the basic features of the plan. Reservoir storage in the South Platte River area reflects a mix of reservoirs, some required to regulate imported water and some to

Table 63 – SPECIFIED NON-FEDERAL PROGRAMS, FRAMEWORK PLAN
PLATTE-NIOBRARA SUBBASIN

Feature	Unit	Planning Area	Amounts 1980	2000	2020
			(Cumulative Above Current)		
Private Ground-water Irrigation	1,000 AC	S. Platte	39	60	80
		N. Platte	20	31	32
		L. Platte	373	818	1,463
		Niobrara	102	127	157
		Subbasin	534	1,036	1,732
State, Local, and Private Recreation	1,000 AC	S. Platte	49	184	376
		N. Platte	12	40	79
		L. Platte	15	61	123
		Niobrara	4	12	24
		Subbasin	80	297	602
Private Land Conservation	1,000 AC	Subbasin	6,188	13,138	19,485

Table 64 – MODIFICATIONS OF EXISTING DEVELOPMENTS, FRAMEWORK PLAN
PLATTE-NIOBRARA SUBBASIN

Feature	Unit	Planning Area	Amounts		
			1980	2000	2020
			(Cumulative Above Current)		
Irrigation System Improvements					
Ditch Consolidation	Miles	S. Platte	33	87	162
		N. Platte	31	84	156
		Subbasin	64	171	318
Ditch Lining	Miles	S. Platte	106	283	530
		N. Platte	126	336	630
		L. Platte	138	367	690
		Subbasin	370	986	1,850
Drainage	1,000 AC	S. Platte	35	92	173
		N. Platte	10	27	51
		L. Platte	23	60	113
		Subbasin	68	179	337
Reservoirs	1,000 AF	S. Platte	3	73	73
Fishing and Recreation Access	Number	S. Platte	250	250	250
		N. Platte	81	89	89
		L. Platte	26	56	56
		Niobrara	29	56	56
		Subbasin	386	451	451
Fish Hatcheries	Number	N. Platte	1	1	1
Refuge Additions	Number	N. Platte	1	1	1
		L. Platte	1	1	1
		Subbasin	2	2	2

regulate potential increased water yields from future forestry and precipitation management programs. Other generally single-purpose reservoirs are required to regulate high flows for local flood protection. Additional storage in the North Platte area is needed for the same general purposes as for the South Platte area except on a much smaller scale. Storage in the Lower Platte area reflects a mixture to provide both high and low flow regulation. In the Niobrara area, storage reservoirs are needed primarily for irrigation, with some related recreation and fish and wildlife purposes. Table 65 summarizes the physical features of this component of the subbasin framework plan.

The surface water control features of the total subbasin framework plan include 436 multiple-purpose reservoirs providing a total storage of 7,961,000 acre-feet. Of this amount, 6,947,000 acre-feet would be provided in 39 reservoirs having individual storage capacities greater than 25,000 acre-feet, with the remaining 1,014,000 acre-feet developed in 397 reservoirs with less than 25,000 acre-feet of individual storage capacity. In addition to the multiple-purpose storage, 1,059,000 acre-feet of single-purpose storage would be provided. Of this total, 601,000 acre-feet would be for recreation, 328,000 acre-feet for flood control, 111,000 acre-feet for fish and wildlife, and 19,000 acre-feet for hydroelectric power. The latter item reflects a possible pump-back storage feature, the storage representing the capacity of an after-bay facility required for this type of power development.

Of the 7,961,000 acre-feet in multiple-purpose impoundments, 1,901,000 acre-feet would be inactive storage, 4,487,000 acre-feet would be for joint beneficial uses, and 1,573,000 acre-feet would be for exclusive flood control. The joint-use storage would be used as follows:

Streamflow Augmentation, Quality	187,000 acre-feet
Irrigation	2,207,000 "
Municipal & Industrial	1,771,000 "
Hydroelectric Power	685,000 "
Recreation, Fish & Wildlife	2,244,000 "
Flood Control	Incidental benefits from regulation

Channel and levee improvements on 1,577 miles of the subbasin's streams are included for local flood protection purposes. This includes 90 miles for protection at the communities of Englewood, Golden, Morrison, Boulder, Longmont, Brush, and Evans in Colorado; Laramie and Casper in Wyoming; and Fremont, Schuyler, Grand Island, Broken Bow, Columbus, Scribner, Winslow, Battle Creek, Verdigre, Kearney, Valley, St. Edward, and Danneborg in Nebraska. The remaining 1,487 miles would be

Table 65 – WATER CONTROL AND RELATED LAND DEVELOPMENT, FRAMEWORK PLAN PLATTE-NIOBRARA SUBBASIN

Features	Unit	Planning Area	Amounts 1980	Amounts 2000	Amounts 2020
			(Cumulative Above Current)		
SURFACE WATER CONTROL					
Storage	1,000 AF	S. Platte	2,363	3,417	4,111
		N. Platte	110	273	659
		L. Platte	1,280	2,185	3,435
		Niobrara	412	793	815
		Subbasin	4,165	6,668	9,020
Local Protection	Miles	S. Platte	22	22	69
		N. Platte	98	228	324
		L. Platte	662	1,023	1,182
		Niobrara	2	2	2
		Subbasin	784	1,275	1,577
Bank Stabilization	Miles	Subbasin	27	80	107
Grade Stabilization	Structures	L. Platte	72	147	200
LAND DEVELOPMENT					
Recreation, Fish and Wildlife	1,000 AC	S. Platte	47	93	136
		N. Platte	7	25	42
		L. Platte	63	122	174
		Niobrara	24	34	40
		Subbasin	141	274	392
Group Drainage	1,000 AC	L. Platte	160	233	343
		Niobrara	0	0	7
		Subbasin	160	233	350
Surface Water Irrigation					
Federal	1,000 AC	N. Platte	3	14	14
		L. Platte	116	234	313
		Niobrara	57	95	110
		Subbasin	176	343	437
Non-Federal	1,000 AC	S. Platte	27	52	83
		N. Platte	7	22	22
		L. Platte	25	44	87
		Subbasin	59	118	192
Public Land Conservation	1,000 AC	Subbasin	387	1,062	1,936

Diversion Dams And Canals Permit Water To Be Used For Irrigation Far From The Stream

associated with watershed improvements. Other in-stream controls would consist of 107 miles of streambanks which would be stabilized against erosion and about 200 grade stabilization structures which would be provided in the Lower Platte area, mostly in the Elkhorn River drainage.

Watershed Impoundments Not Only Control Runoff But Provide Habitat For Waterfowl

Land development features include 392,000 acres for recreation and fish and wildlife; 350,000 acres of group drainage systems in the Lower Platte and Niobrara areas; the irrigation by surface sources of 629,000 acres of new land; supplemental water and facilities for 208,200 acres of presently developed land; and supplemental water, but no facilities, for 166,000 acres of presently irrigated lands. Land conservation practices would be applied to almost 2 million acres of federally owned land.

In order to more fully utilize the water resources of the subbasin, the framework plan includes features for diverting 230,000 acre-feet of water from the Niobrara River drainage to the Loup and Elkhorn drainages of the Platte River system. Similarly, an export of 500,000 acre-feet from the Platte River system to the Kansas River system is contemplated in order to provide for ground-water recharge and further use in the Kansas River system. The net export from the Platte River system would be 270,000 acre-feet. These import-export features probably would not be required until some time

after the year 2000 and reflect an objective of transferring surplus waters to areas with probable deficiencies as well as to maximize water usage for beneficial purposes. The multiple-purpose storage and cost values shown for this subbasin do not include provisions for the trans-basin diversion features contemplated for the export of surface water to the Kansas subbasin. Rather, they were all included with the Kansas subbasin framework.

Environmental Enhancement and Non-Structural Measures

Other environmental enhancements, not included in preceding plan features, and non-structural measures were delineated as a part of the total subbasin framework plan. The environmental features include sufficient water and sewage treatment facilities to meet future needs and are in consonance with planning criteria; the development of 143,000 acres of land for wildlife management purposes; the development of two fish hatcheries and 38 fish impoundments; the preservation of 120 miles of the middle portion of the Niobrara River as a scenic river or waterway; and the development of 21 special use recreation areas and 1,775 miles of trails for National designation. Table 66 presents the plan features for environmental enhancement.

Non-structural elements of the subbasin framework plan include the preparation of 139 flood hazard reports covering 1,342,000 acres of flood plain lands and forest and precipitation management programs to yield an average water supply of 538,000 acre-feet annually. These features are outlined in table 67.

Table 66 – ENVIRONMENTAL ENHANCEMENT, FRAMEWORK PLAN
PLATTE-NIOBRARA SUBBASIN

Feature	Unit	Planning Area	Amounts		
			1980	2000	2020
			(Cumulative Above Current)		
Sewage Treatment Plants[1]	Number	Subbasin	350	400	500
Water Supply and Treatment	1,000 AF/YR	Subbasin	234	537	954
Fish and Wildlife Management Areas	1,000 AC	S. Platte	20	40	59
		N. Platte	28	56	84
		Subbasin	48	96	143
Fish Hatcheries	Number	S. Platte	2	2	2
Fish Impoundments	Number	S. Platte	15	15	15
		N. Platte	7	7	7
		L. Platte	5	5	16
		Subbasin	27	27	38
Scenic Rivers	Miles	Niobrara	0	120	120
Special Areas	Number	S. Platte	3	5	5
		N. Platte	4	8	8
		L. Platte	3	6	6
		Niobrara	1	2	2
		Subbasin	11	21	21
Trails	Miles	Subbasin	350	475	1,775

[1] Includes existing plants.

Table 67 – NON-STRUCTURAL MEASURES, FRAMEWORK PLAN
PLATTE-NIOBRARA SUBBASIN

Feature	Unit	Planning Area	Amounts		
			1980	2000	2020
			(Cumulative Above Current)		
Flood Plain Management					
Area	1,000 AC	Subbasin	79	828	1,342
Flood Hazard Reports	Number	Subbasin	34	81	139
Water Yield Increases					
Forest Management	1,000 AF	S. Platte	20	71	71
		N. Platte	39	142	142
		Subbasin	59	213	213
Precipitation Management	1,000 AF	S. Platte	24	73	243
		N. Platte	70	145	295
		Subbasin	94	218	538

Land and Water Changes

Net land use changes that would result from implementation of the features of the subbasin framework plan are shown in table 68. The conversions of land for various purposes reflect the same considerations described previously for other subbasins.

Water supply studies indicate a streamflow depletion of about 2.6 million acre-feet on the average by year 2020 and a ground-water depletion of about 1.5 million acre-feet annually at the same time level. The withdrawals and consumptive uses of water from both sources and for various uses are presented in table 69.

As can be noted from table 69, a very high rate of consumptive use would result from the subbasin framework plan – withdrawals of about 5.8 million acre-feet and consumption of about 4.1 million acre-feet. This reflects not only a high degree of regulation, but also the use and re-use of available water. The adequacy of water supply in support of the plan is discussed subsequently in this chapter.

Table 68 – LAND USE CHANGES, FRAMEWORK PLAN
PLATTE-NIOBRARA SUBBASIN

Principal Use	Net Land Use Changes			
	1965-1980	1980-2000	2000-2020	1965-2020
	(Thousand Acres)			
Irrigated Cropland	+709	+652	+739	+2,100
Non-irrigated Cropland	- 754	- 718	- 835	- 2,307
Forest and Woodland	- 71	- 88	- 146	- 305
Pasture and Range	- 539	- 618	- 848	- 2,005
Transportation, Urban, & Built-up	+236	+446	+718	+1,400
Other (Rec., F&WL, and Other Uses)	+305	+234	+235	+ 774
Water	+114	+ 92	+137	+ 343

Table 69 – WATER WITHDRAWALS, DEPLETIONS, AND OTHER CHANGES
FRAMEWORK PLAN – PLATTE-NIOBRARA SUBBASIN

Service	*Withdrawals*						*Depletions*					
	Ground			Surface			Ground			Surface		
	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
	(Cumulative Above Current – Thousand Acre-feet/Year)											
Irrigation	438	1,006	1,743	1,308	2,173	2,963	346	800	1,389	830	1,391	1,803
M&I, Rural Domestic	60	97	132	174	440	822	1	9	20	166	333	486
Thermal Power				74	- 154	- 252				15	62	99
Livestock	28	59	99	30	58	88	26	54	87	32	63	98
Land Conservation				25	74	123				25	74	123
Wetlands, Fish and Wildlife				5	5	8				5	5	8
Evaporation				114	314	564				114	314	564
Imports				- 105	- 337	- 337				- 105	- 337	- 337
Exports				0	190	500				0	190	500
Forest Management				- 59	- 213	- 213				- 59	- 213	- 213
Precipitation Management				- 94	- 218	- 538				- 94	- 218	- 538
Total	526	1,162	1,974	1,472	2,332	3,728	373	863	1,496	929	1,664	2,593

The effect of ground-water development on streamflow is expected to vary widely among the individual stream systems within the subbasin. Because of this variation, streamflow depletion factors ranging from 10 to 100 percent were applied in the various planning areas.

In the South Platte drainage, the surface water system has attained almost maximum development and a ground-water system which in many areas is sustained largely by recharge from ditch irrigation systems. In most of the drainage in Colorado, ground water is closely related to surface irrigation systems and extractions are replenished from surface applications and by recharge from precipitation. Without the surface system, many well systems would not sustain ground-water withdrawals on a perennial basis.

Much of the same situation exists in most of the North Platte drainage. In the stream valleys of Wyoming, sustained ground-water withdrawal results generally, in depletions to streamflow. In Nebraska, however, it is believed that aquifers in some locations may be adequate to permit ground-water withdrawals independent of surface conditions.

In the Loup, Elkhorn, and Niobrara drainages, the opportunity is extensive for both surface and ground-water developments. Substantial water bearing aquifers are available from which ground water may be used over a long period with only minor effects on streamflow. A

sliding scale estimate was used to reflect streamflow depletions from ground-water withdrawal. These would be 5, 10, and 15 percent for successive 20-year periods of net ground-water removal.

The Sandhills region of north-central and northwestern Nebraska, which is drained primarily by the Loup and Niobrara Rivers, is underlain by a thick sequence of saturated permeable rocks. An estimated 12 million acre-feet of water infiltrate the sandy soil annually, and about 80 percent of this amount is returned to the atmosphere by evapotranspiration. A significant potential exists in this region for salvage of water without appreciable depletion of streamflow. Controlled ground-water pumpage could be used to lower ground-water levels in order to reduce evapotranspiration rates.

The lower Platte River area is believed to present large opportunities for either ground or surface water developments. Ground-water withdrawals are considered to be more directly related to streamflow than in the Loup, Elkhorn, and Niobrara drainages, but not dependent on surface replenishment. It is estimated that ground-water extractions will be possible on an extensive scale, but depletions will be reflected in diminished streamflow both sooner and in greater amounts than for the drainages previously cited. In the lower Platte River area, a similar sliding scale was used, but with streamflow depletion factors of 10, 30, and 50 percent for successive 20-year periods.

Costs

Estimates of first costs and annual operation, maintenance, and replacement costs for all features of the subbasin framework plan were made. As shown in figure 35, the total first cost of the subbasin framework plan would be about $5.2 billion, with investment requirements at the bench mark years of 1980 and 2000 approximating $1.7 billion and $3.5 billion, respectively. Annual operation, maintenance, and replacement costs would range from $45.3 million by 1980 to $132.6 million by 2020.

The first costs were also distributed to each functional feature of the subbasin framework plan and are shown graphically in figure 36. As can be noted from that figure, the largest share (22 percent) would be for

FIGURE 35
ESTIMATED FIRST COSTS AND
ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENTS
FRAMEWORK PLAN
PLATTE-NIOBRARA SUBBASIN
(cumulative above current)

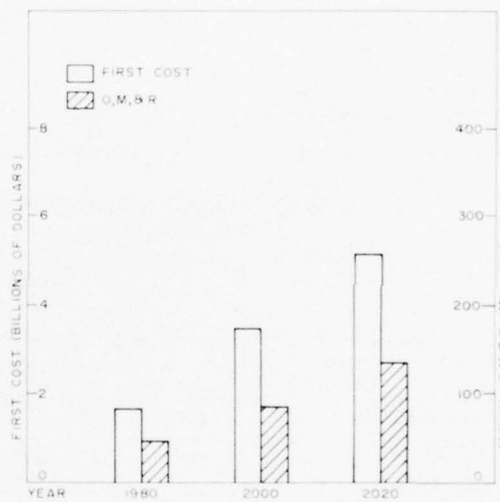


FIGURE 36
DISTRIBUTION OF COSTS BY FUNCTIONAL PURPOSES
FRAMEWORK PLAN
PLATTE-NIOBRARA SUBBASIN

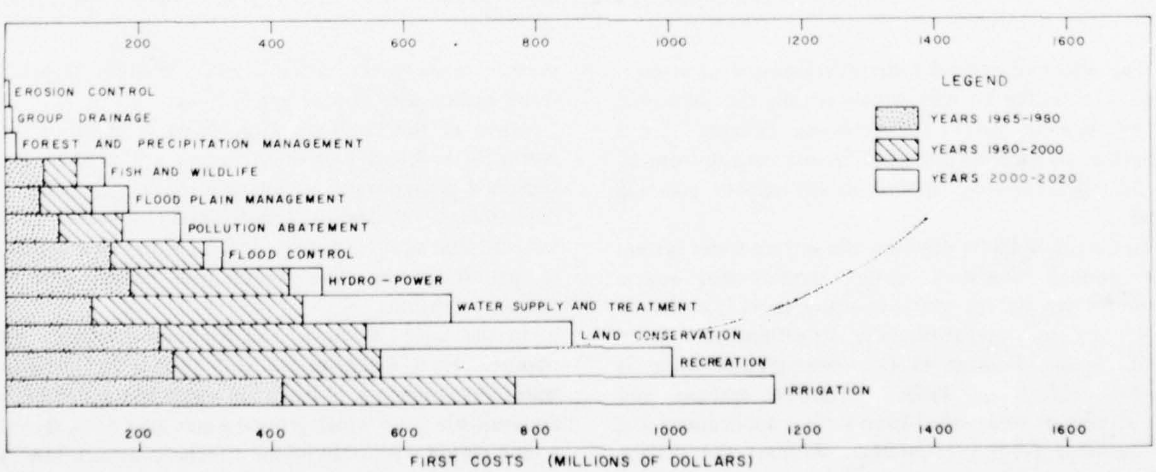


Table 70 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY — PLATTE-NIOBRARA SUBBASIN

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						346.4		346.4
State & Local Recreation						562.4	341.8 1/	220.6
National Recreation Area								
Private Land Conservation						839.0	419.5	419.5
Irrigation Rehabilitation	177.0	177.0		177.0				
Access						10.3		10.3
Refuges	2.3	2.3						
Hatcheries	2.3	1.2			1.1			
Reservoirs						48.4		48.4
Water Control and Related Land								
Single Purpose F. C.	115.2	92.2			23.0			
Other Single Purpose Res.	352.2	352.2		352.2				
Grade Stabilization	4.1	3.3			.8			
Bank Stabilization	4.0	2.8			1.2			
M. P. Reservoirs	1,272.0	(633.5)	(638.5)	(631.1)				
Water Quality			48.4					
Irrigation			168.4	168.4				
M & I			164.5	164.5				
Power		87.0	44.2	131.2				
Recreation		327.0	106.5	163.5				
Fish and Wildlife		7.0	106.5	3.5				
Flood Control		212.5						
Surface Water Irrigation	413.9	413.9		413.9		53.4		53.4
Group Drainage	15.0	7.6			7.4			
Public Land Conservation	17.5	17.5						
Environ. and Non-Structural								
Sewage Treatment						223.0	66.9	156.1
Water Supply & Treatment						459.7	229.9	229.8
Fish and Wildlife								
Wetlands								
Management Areas						23.9	12.0	11.9
Fish Hatcheries	4.6	2.3			2.3			
Fish Impoundments	7.1	3.6			3.5			
Scenic Rivers	.7	.7						
Trails	5.2	5.2						
Flood Plain Management	2.6	2.6				186.5		186.5
Forest Management	.7	.7						
Precip. Management	15.3	15.3						
Totals	2,411.7	1,733.9	638.5	1,574.2	39.3	2,753.0	1,070.1	1,682.9
			1965-2020 Total: 5,164.7					

1/ Includes $194.7 million for recreation facilities on Federal lands which would be federally financed but whose costs would not be included under the grant program.

TOTAL RESERVOIR STORAGE
IN THE SUBBASIN FRAMEWORK PLAN
(CUMULATIVE ABOVE CURRENT)

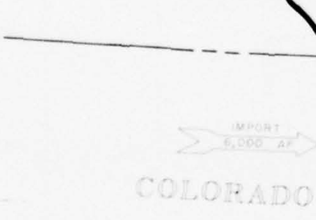
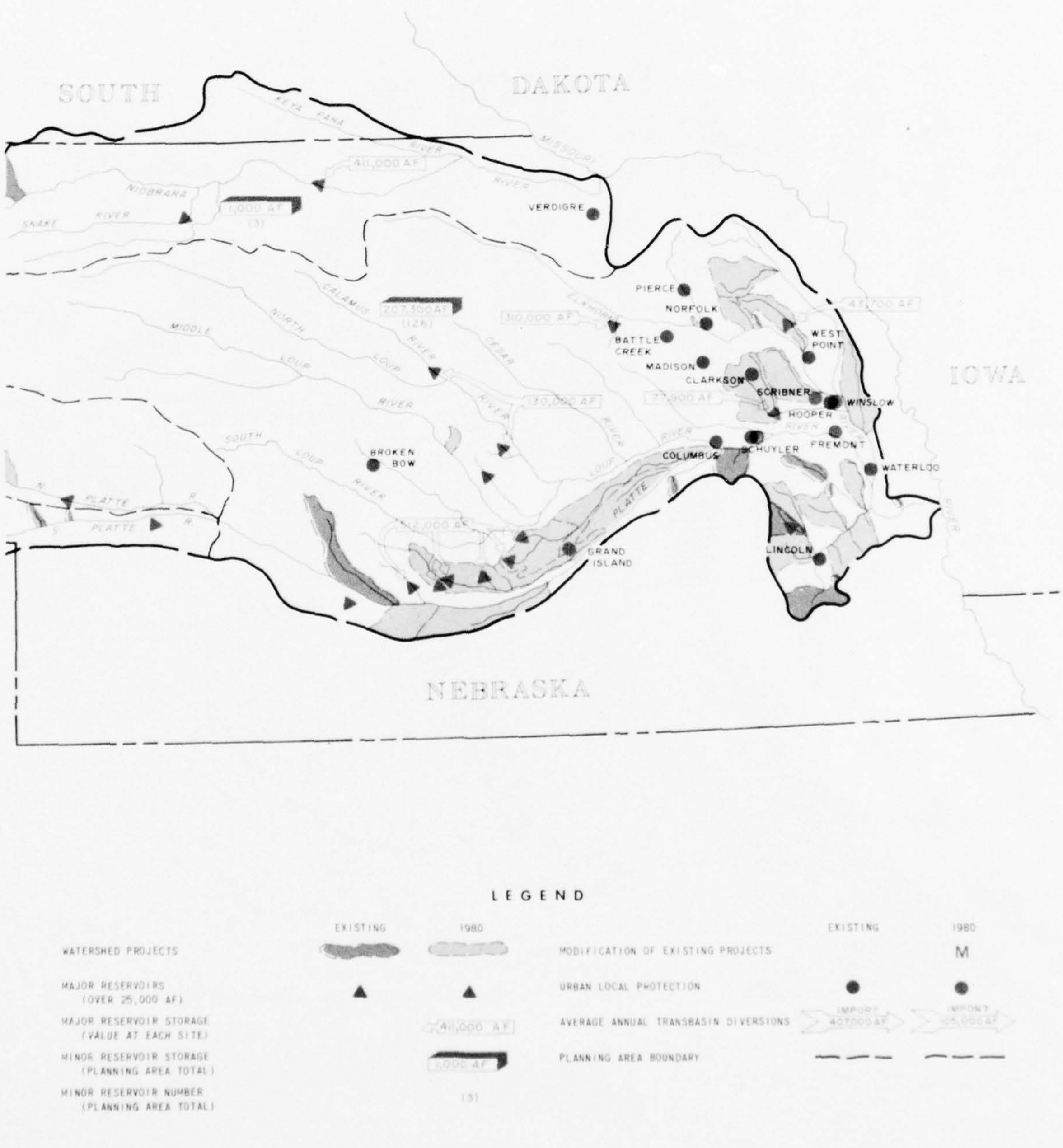


FIGURE 37

PLATTE-NIOBRARA SUBBASIN

PRINCIPAL WATER CONTROL FEATURES

EXISTING AND 1980 FRAMEWORK PLAN




N
WYOMING
COLORADO
SWEETWATER
RIVER
M
NORTH
RIVER
PLATTE
NIOBRARA
RIVER
RIVER
NORTH
PLATTE
RIVER
LARAMIE
M
LODGEPOLE
CREEK
RIVER
PLATTE
SOUTH
NET LAND USE CHANGES
SUBBASIN FRAMEWORK PLAN
IRRIGATED CROPLAND
1965 - 1980
1980 - 2000
2000 - 2020
NON-IRRIGATED CROPLAND
2000 - 2020
1980 - 2000
1965 - 1980
FOREST AND WOODLAND
PASTURE AND RANGE
TRANSPORTATION
URBAN, & BUILT-UP
OTHER
WATER
-2000 -1500 -1000 -500 0 +500 +1000 +1500 +2000
THOUSAND ACRES
SCALE 1:3,520,000
SCALE 25 0 25 50 75 MILES
APPROXIMATE

FIGURE 38

PLATTE-NIOBRARA SUBBASIN

RELATED LAND DEVELOPMENT FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

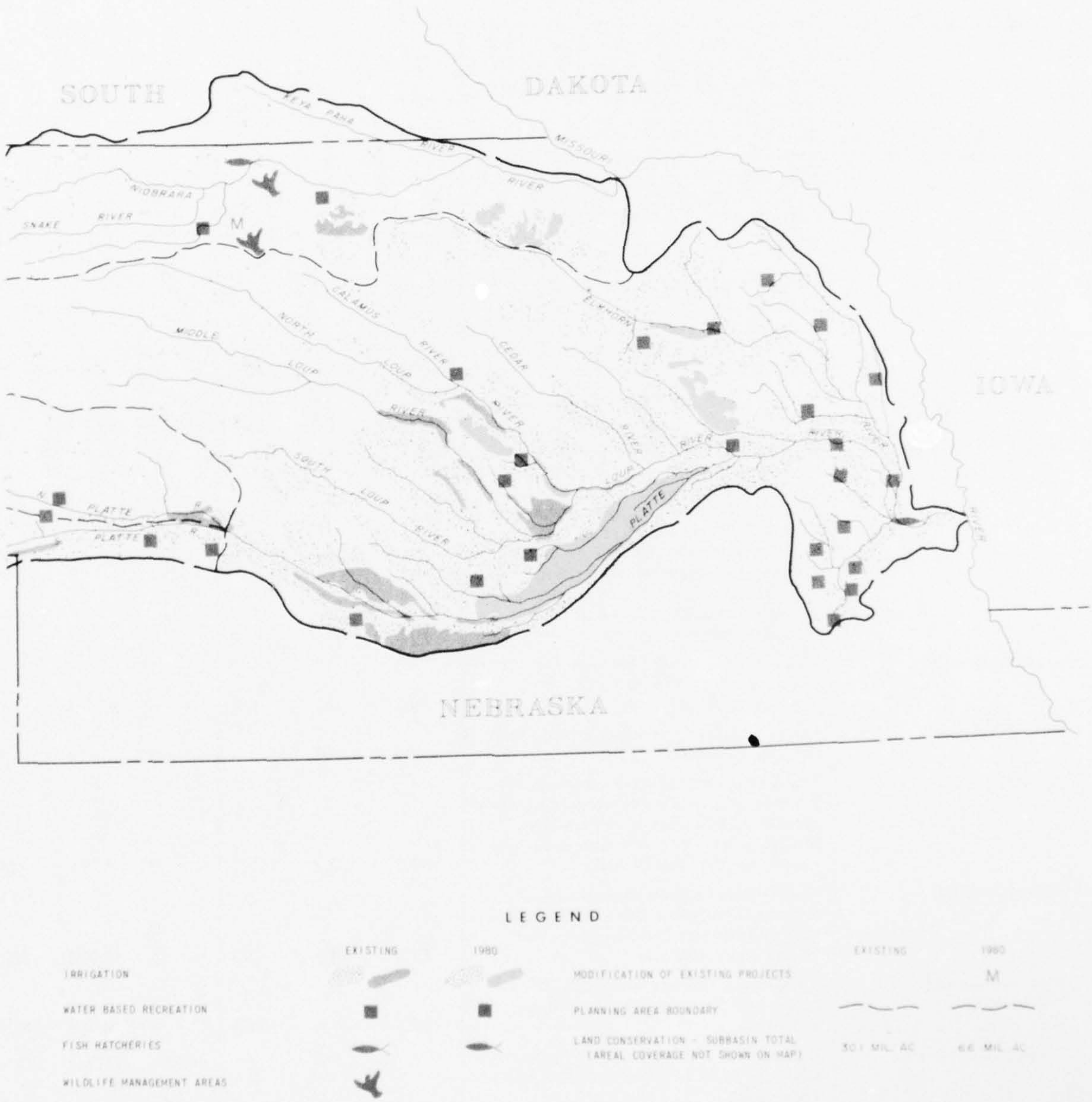


Table 71 – FRAMEWORK PLAN FOR 1980 – PLATTE-NIOBRARA SUBBASIN

Plan Feature	Description and Purpose	Initial First Costs			Annual Operation, Maintenance and Replacement Costs		
		Federal	Non-Fed	Total	Federal	Non-Fed	Total
		($ Million)			($ Thousand)		
Storage Reservoirs							
Modifications	Raise embankment of Boulder Reservoir on a tributary of St. Vrain Creek to provide 3,000 acre-feet of additional storage for M&I water.	0	0.6	0.6	0	6	6
Single-purpose Impoundments	Reservoirs with 46,000 acre-feet for recreation, 291,000 acre-feet for flood control, and 93,000 acre-feet for fish and wildlife. Power facilities for pump-back storage are also included.	197.8	12.7	210.5	0	768	768
Multi-purpose Impoundments, Major and Minor	15 impoundments having 3,460,000 acre-feet of storage and 143 minor reservoirs with a capacity of 275,000 acre-feet for water quality, irrigation, M&I, power, recreation, fish & wildlife, and flood control.	398.0	0	398.0	1,082	7,154	8,236
Irrigation							
New Systems and Rehabilitation	Provide 769,000 acres of irrigation subbasin-wide, consolidate 64 miles of ditches, line 370 miles of ditches, and drain 68,000 acres providing the equivalent of 115,000 new irrigated acres.	209.5	133.6	343.1	0	7,070	7,070
Group Drainage	Provide 160,000 acres of public or group drainage.	3.2	3.2	6.4	0	64	64
Local Flood Protection	Channel and levee improvements involving 784 miles for protection of Englewood, Golden, Morrison, Boulder, Longmont, Brush, and Evans, Colo. and Laramie and Casper, Wyo. and Sidney, Fremont, Schuyler, Grand Island, Broken Bow, Columbus, Scribner, Winslow, Battle Creek, and Verdigre, Nebr., and both urban and agricultural areas associated with watershed improvements.	26.2	6.4	32.6	0	287	287
Grade Stabilization	72 grade stabilization structures for erosion control of tributaries to the lower Platte River.	0.5	0.1	0.6	0	3	3
Bank Stabilization	Bank protection on the lower Platte River covering 27 miles.	0.7	0.3	1.0	0	10	10
Recreation	The development of 48,000 acres by the State, local, and private sector; and development of 32,000 acres on Federal land; providing 386 new access sites to existing water, and 350 miles of trails.	67.0	102.7	169.7	0	5,808	5,808
Fish and Wildlife	48,000 acres for game management, 2 refuge additions, one fish hatchery addition, and two new fish hatcheries, and 27 fish impoundments.	18.8	16.2	35.0	0	2,382	2,382
Water Supply and Treatment	Treatment facilities to serve 903,000 people and development of individual supplies.	57.5	57.4	114.9	0	6,260	6,260
Sewage Treatment	Enlargement of 168 secondary facilities, additions to 52 secondary facilities, and construction of 130 new secondary facilities.	21.3	49.7	71.0	0	6,589	6,589
Water Yield Management	Forestry practices to yield 59,000 acre-feet of additional water and precipitation management to produce 94,000 acre-feet of additional water.	2.0	0	2.0	2	0	2

Table 71 (Continued)

Plan Feature	Description and Purpose	Initial First Costs			Annual Operation, Maintenance and Replacement Costs		
		Federal	Non-Fed	Total	Federal	Non-Fed	Total
		($ Million)			($ Thousand)		
Land Conservation	Land treatment measures for 6,188,000 acres of private land and 387,000 acres of federally owned land.	120.0	116.0	236.0	40	7,500	7,540
Flood Plain Management	Preparation of 34 flood hazard reports covering 79,000 acres of flood plains.	0.8	51.1	51.9	48	255	303
Total		1,123.3	550.0	1,673.3	1,172	44,156	45,328

irrigation, followed by recreation (19 percent), land conservation (16 percent), and water supply and treatment (13 percent).

First costs were further disaggregated to reflect cost-sharing relationships. Based on existing legal and policy considerations, initial Federal investments of $2,372.4 million would be required, of which $1,574.2 million would have to be reimbursed by non-Federal entities over the long-term future as well as provide $39.3 million for initial cost-sharing purposes. Similarly, non-Federal programs with an estimated first cost of $2,753 million could result in a net non-Federal investment of $1,682.9 million because of Federal grant and assistance programs. On the basis of initial investments the total first costs would be shared 67 percent by the Federal Government and 33 percent by non-Federal institutions. On the basis of net costs the relationship would be 36 percent Federal and 64 percent non-Federal. Distributed costs together with cost-sharing requirements are shown in table 70.

Short-Range Framework Plan

The short-range (1980) features of the subbasin framework plan are summarized in table 71. Figures 37 and 38 show the major features of the 1980 framework plan by geographical location.

MIDDLE MISSOURI SUBBASIN

The Middle Missouri Subbasin, located in the east-central part of the Missouri Basin, encompasses an area of about 24,600 square miles. Although it is primarily an agricultural area, with 76 percent of the land under cultivation, it includes such metropolitan centers as Sioux City and Council Bluffs, Iowa; Omaha, Nebr.; Atchison and Leavenworth, Kans.; and St. Joseph, Mo.

Water Resources

Average annual runoff ranges from about 3 inches in the northern part of the subbasin to almost 8 inches at the southern end. However, "averages" are misleading since the area is subjected to recurrent cycles of high and low flows, wet years and dry years. During dry years, the annual flow may average about 15 percent of the mean annual volume, while in wet years, the volume may be over two and one-half times greater than during an average year. To further complicate the water management picture, about 80 percent of the total volume of runoff at a given point in a stream system during a given year may actually pass that point less than 20 percent of the time, with much of the total occurring as flood flow in 1 to 2 days.

Ground water is used for municipal, industrial, rural domestic, and irrigation purposes. Ground-water withdrawals are prevalent in the tributary areas with surface withdrawals being mainly from the Missouri River. Ground-water supplies are generally adequate for most purposes except irrigation. The availability of ground-water supplies for irrigation is generally limited to stream valley areas, especially the Missouri River flood plain. As an indication of the increase in ground-water use, it is estimated that average annual withdrawals were 83,000; 128,000; and 135,000 acre-feet for the 5-year periods ending in 1955, 1960, and 1965, respectively.

Within the subbasin in 1965 there were 255 communities providing central water service to 941,000 people representing 73 percent of the 1960 population. Of these communities, 182 had sewerage systems with 22 providing primary treatment and 118 secondary treatment. With this treatment the total waste load of about 3.4 million population equivalents was reduced to about 1.9 million P.E.

In 1965 about 480,000 acre-feet of water were diverted for cooling in thermal-electric power generation. There are several such generating stations on the Missouri River at this time and two large nuclear fuel plants are under construction near Omaha, Nebr. The flow in the river is controlled by a major upstream reservoir system and present flows are believed adequate to handle the estimated thermal discharges without serious problems. If flows should be reduced substantially, off-stream cooling water might be required to prevent thermal pollution.

While some of the industrial organic wastes are treated by municipal treatment plants, large quantities

of separate industrial wastes are not adequately treated. There have been three enforcement actions under the Federal Water Pollution Control Act in the subbasin for Sioux City, Ia., Omaha, Nebr., and St. Joseph, Mo. Sioux City has complied with the enforcement-conference recommendations, but surveys are needed to determine the impact of recent additions to the industrial complex on waste treatment works. Omaha has not yet complied due to delays in construction of industrial waste-handling facilities for paunch manure and other packing plant wastes, but early completion is scheduled. St. Joseph has complied, with the exception of completion of interceptor sewers held up by rights-of-way problems caused by interstate highway plans.

Fisheries in the subbasin reaches of half a dozen streams (over 340 miles) are adversely affected by pollution, including over 160 miles of the Missouri River and almost 100 miles of the Little Sioux River.

Sufficient quality-of-water data are not available to permit a direct analysis of the average dissolved solids concentration of the 7.7 million acre-feet of streamflow leaving the subbasin. The dissolved solids concentration of the Missouri River at Sioux City is about 470 mg/l and at Kansas City about 400 mg/l. The subbasin contributes about half of the total inflow between those two points and, considering the estimates of concentrations for the remaining inflow, the average dissolved solids concentration in the outflow from the subbasin is about 250 mg/l. With only 103,000 acres of irrigation in the subbasin, the dissolved solids concentration is primarily from the natural runoff except as increased by the effluents from municipal and industrial use.

Sediment yields range from as low as 0.2 acre-foot per square mile in the extreme northern parts of the area to as high as 6 acre-feet per square mile in the middle portion of the subbasin. High sediment transport affects the use to which streamflows are put, the environmental characteristics of the stream, and the problems associated with developing reservoirs in order to manage surface waters.

Flood and Erosion Control

Existing flood and erosion control projects are summarized in table 72. These improvements are primarily single-purpose in character, although on the Missouri River, multiple benefits are being derived from upstream main stem improvements, navigation in conjunction with the main stem bank protection, and some recreation and fish and wildlife values associated with watershed projects.

Table 72 – EXISTING FLOOD AND EROSION CONTROL PROJECTS
MIDDLE MISSOURI SUBBASIN

Type	No.	Levees & Channels	Total Storage	Area Protected	Annual Damages Prevented
		(Miles)	(1,000 AF)	(1,000 AC)	($1,000)
Upstream Watershed Projects	40				
Flood Retarding	488		131	136	2,023
Channel Improvement		110			
Grade Stabilization	1,460				
Levees and Channels	12	757		483	24,071
Bank Protection	1	237		175	28

Of the 2,860,000 acres of land subject to flooding in the subbasin, 1,260,000 are located on the Missouri River flood plain. All of the latter are protected to some degree by the main stem reservoirs and agricultural levees. In general, flood problems along the main stem are not significant except in the lower reaches of the subbasin below the confluence of the Platte River of Nebraska. In the areas tributary to the Missouri River, however, 1,067,000 acres, or 76 percent, of the 1,400,000 acres do not have any flood protection. In the unprotected areas floods occur with frequencies of from 1 to every 3 years.

In the absence of the existing projects, annual flood losses would be on the order of $30.1 million, of which $13.9 million would be in the Missouri River flood plain. Existing projects reduce these damages to $15.6 million, of which $3.3 million are in the Missouri River flood plain. Along the Missouri River, average annual flood damages have been reduced by 70 percent, while in the tributary areas the damage reductions approximate 27 percent. It is evident, therefore, that existing flood problems are confined mainly to Missouri River tributaries, solution of which would probably lead to further damage reductions along the main stem.

Stabilization of the Missouri River in the reach which traverses the Middle Missouri Subbasin has virtually eliminated the erosion threat on the main stem. However, extensive streambank erosion and gullying are prevalent on the tributaries. Much of this streambank erosion results from channelization carried out in the past, lack of maintenance of initial construction, and the consequent degradation of most stream channels. About 1,800 bank-miles, or 2.7 percent of the existing channel banks, have received serious erosion with average annual losses estimated to be $1,033,000. Measures to control bank erosion have been undertaken only as emergency or temporary measures by individuals and local drainage districts when problems have arisen.

This subbasin has the greatest gully erosion problems in the entire basin. It is estimated that about 21,000

Erosion In This Subbasin Is Widespread

Erosion Can Be Controlled As Illustrated

acres of land are damaged each year by gullies. Assuming that this rate will continue with little or no recovery, about ¼ million acres of land would be damaged in a 50-year period with an estimated annual loss of approximately $8.4 million.

Water Supply

Both ground and surface water are being withdrawn for domestic, industrial, agricultural, and power uses. Surface and ground supplies used for agricultural purposes are for irrigation and livestock water. About 103,000 acres of land are presently being irrigated, 85,000 from ground water and 18,000 from surface supplies. The amount of water diverted for this purpose is on the order of 103,000 acre-feet annually. Irrigation in the subbasin has been exhibiting strong growth, especially as a means for dampening the effects of seasonal moisture deficiencies and for maintaining proper soil-moisture balances for maximum production. Surface-water irrigation is hampered by low base flows in many of the streams at the time water is required, though some individuals have constructed small impoundments to overcome this handicap. Soil types are adequate, with minimal drainage problems to support expanding supplemental irrigation. The only physical constraints to further expansion of supplemental irrigation are the fluctuating streamflows and inadequate ground-water supplies in the upper tributary areas.

Livestock water supplies in the subbasin are adequate to meet current demands except in some areas where, during prolonged droughts, farm ponds may be depleted and ground-water levels decline. About 84 percent of livestock water is supplied from ground sources, the remainder from surface water. There are 16,000 farm ponds which provide 50 percent of the surface supply. In general, there are sufficient water developments to support the livestock water demands.

The water supply requirements for domestic, industrial, and power generation needs are currently being met throughout the subbasin. Table 73 summarizes existing facilities and uses.

The single largest user of water in the above category is the electric power industry. A major portion of the electrical generating plants in the subbasin are thermo-electric with a total installed capacity of 1,408 mw. Of the 6.1 billion kwh of electricity used in 1965, 5.5 billion kwh were generated within the subbasin, the remainder being imported. Streamflow diversions for cooling-water purposes amounted to 480,000 acre-feet, but only 5,800 acre-feet were consumed. In perspective, the total gross withdrawal requirements for all purposes cited above were 612,600 acre-feet. An emerging problem with respect to thermal cooling water requirements is the potential for thermal pollution (raising of water temperatures in the receiving stream). At the present time, power plants are located where ample cooling water is available and no significant thermal pollution is apparent.

Table 73 – EXISTING DOMESTIC, INDUSTRIAL, AND POWER WATER USES, MIDDLE MISSOURI SUBBASIN

Item	Missouri River	Tributaries	Total
Population Served in 1965	600,000	341,000	941,000
Number of Systems			
Municipal, Industrial, and Rural Domestic	5	250	255
Industrial, Including Power	20	17	37
Power Only	8	6	14
Current Uses (Acre-feet per year)			
All, Including Power	33,800	578,800	612,600
Power Only			480,000

Fish, Wildlife, and Recreation

Developments and facilities for these inter-related functions consist of 63,000 acres of impoundments for fishing; 96,000 acres for general recreation; 3,000 miles of classified fishing streams; 15 million acres for wildlife, with 281,000 acres primarily devoted to wildlife production; and some 37,000 acres of land and 23,000 acres of water dedicated primarily to general recreation. The estimated capacity of the fishing resources is 2.6 million fisherman-days with current use approximating 1.7 million fisherman-days. With respect to general recreation, 16 million recreation-days were recorded in 1965.

The current indicated deficiencies in meeting demands for fish, wildlife, and recreation can be traced to the high effective and latent demand associated with the urban areas within and adjacent to the subbasin. If capacity in this category was increased materially within relatively short distances of the urban areas, the use rate or "unfulfilled demand" would be met. However, recreational outlets of all types, especially water based opportunities, are urgently needed near these large population centers.

Land Conservation and Drainage

Currently, 11.2 million acres of the privately owned lands in the subbasin are used for crop production, 2.5 million acres are used for pasture and range, 631 thousand acres are in forest and woodlands, 447 thousand acres are in other agricultural uses, and 773 thousand acres are in non-agricultural uses. About 103 thousand acres of the cropland are irrigated annually. About 1,000 acres of Federal lands are

Access To Existing Water Permits Recreation Usage

used to produce forest products. An additional 15 thousand acres of Federal land are used for non-agricultural purposes.

Of the 11.2 million acres used for cropland, 96 percent, or 10.8 million acres, are suitable for sustained cultivation with proper management and conservation measures. The remaining 427 thousand acres of cropland are not suitable for continuous cultivation without sustaining damage to the soil resources. Conversely, about 300 thousand acres of pasture and range are physically suitable and can be used for sustained crop production with proper management and conservation measures.

Wind and water erosion seriously affect lands in the subbasin. Through their own efforts and with Federal technical assistance and cost-sharing available to them, the owners and operators have installed adequate conservation treatment and management on 5.9 million acres of the private agricultural lands. Management-type practices on 3.6 million acres and mechanical or vegetative-type practices on 6 million acres are needed to provide adequate levels of conservation treatment and management.

On federally owned lands 14 thousand acres, or 88 percent, are currently treated and managed adequately. The remaining 2 thousand acres in the subbasin need improved conservation treatment and management for sustained use without deterioration.

There are approximately 2.5 million acres of agricultural land in the subbasin subject to excess water problems. Excess water problems caused by irrigation are of slight consequence within this subbasin. Currently, 1.3 million acres of cropland have been provided with adequate drainage. Of the remaining 1.2 million acres of land subject to excess water, 858 thousand acres are considered potentially suitable and feasible to drain. About 52 percent of this area is currently cultivated and current use would be improved by allowing timely operations. An additional 355 thousand acres of pasture and range and 52 thousand acres of forest and woodland are subject to problems of excess water and are suitable for conversion to cultivated uses. About 490,000 acres will need project-type measures to remove excess water.

About 275 thousand acres, or 11 percent of the land with excess water problems, are considered infeasible to drain. Of this total, 61 thousand acres are currently used for cropland and should be converted to non-crop uses. This and the remainder should be used for grazing and woodlands and managed to utilize its natural value as wildlife habitat.

Planning Objectives

The area of the Middle Missouri Subbasin, smallest of the eight tributary subbasins, is devoted principally to agriculture, especially livestock production and feeding. However, four major metropolitan areas, Sioux City, Council Bluffs, Omaha, and St. Joseph are located within the subbasin along the banks of the Missouri River. All of the tributary streams in the subbasin are relatively small with extreme variations in their streamflow. Most of the land area is of loess soil which is highly erodible. This area is the highest producer of sediment in the region.

With expanding urban requirements and intensification of agriculture in the subbasin, it is inevitable that competition for land and water resources between urban and rural sectors should develop. With the major metropolitan areas having easy access to the ample water supplies of the Missouri River, urban demands for expansion of the cities and for recreational outlets obviously must be at the expense of the rural sector. The principal area of competition is for water-based recreation areas which remove significant areas from agricultural production. Since the cities are dependent to some extent on the production from the agricultural sector, some balance must be sought that will maintain a healthy and growing economic community.

Such balance can be achieved if the water supplies of the tributaries are regulated to provide for agricultural supplies and for other urban and rural uses. This would require reservoir systems that can control high and low flows for all possible beneficial uses and the multiple-use of these systems for recreational activities emanating primarily from the urban areas. However, in order to intensify and increase the productive potential of the agricultural areas the erosion problem must be dampened. This is required not only to stabilize the land base, but also to reduce the sediment storage requirements in the reservoir systems. For example, very few major impoundments have been constructed in western Iowa because of the high costs, much of which can be

attributed to storage requirements to accommodate sediment.

The primary objectives for the subbasin, therefore, are to maintain and enhance a balanced urban-rural economy. To this end, a multi-use concept must be adopted generally as outlined. To explore alternatives for maximizing various uses of land and water resources would prove unfruitful here. Accordingly, plan formulation was aimed at control of the water resources of the tributary streams, generally to maximize regulation of surface water, and of development of the related land on a multi-use basis to the extent practicable.

Specified Non-Federal Programs and Modifications of Existing Developments

Private ground-water development, which includes about 74,000 acres of irrigated land at the present time, is expected to show accelerating growth over the projection period, approaching an added 1.3 million acres by 2020. Most of this development would take place in the Missouri River flood plain where ground-water supplies are adequate and developmental costs are within the financial capability of individual operators. Recreational development by the State, local, and private sectors is expected to continue at an expanding rate, primarily in and around the urban communities. Land conservation practices, which are essential to this area, are expected to be applied in the future at about the rate of historical application. In order to increase the fishing and recreation capacity of the subbasin, additional access, mostly to the Missouri River and some of its abandoned channels, or ox-bows, would be provided as a part of the subbasin framework plan. There are no other significant opportunities for improving existing developments to provide expanding goods and services. The composition of these features of the framework plan is presented in table 74.

Table 74 – SPECIFIED NON-FEDERAL PROGRAMS AND MODIFICATIONS OF EXISTING DEVELOPMENTS, FRAMEWORK PLAN
MIDDLE MISSOURI SUBBASIN

Feature	Unit	Amounts 1980	2000	2020
		(Cumulative Above Current)		
SPECIFIED NON-FEDERAL PROGRAMS				
Private Ground-water Irrigation	1,000 AC	218	754	1,282
State, Local, and Private Recreation	1,000 AC	89	155	232
Private Land Conservation	1,000 AC	1,491	3,289	5,386
MODIFICATION OF EXISTING DEVELOPMENTS				
Fishing & Recreation Access	Number	48	57	57
Refuge Additions	Number	3	3	3

Water Control and Related Land Development

The water control features and associated land developments are the key to meeting future demands for land and water in this subbasin. Extensive surface water control by reservoirs and in-channel control structures are integral elements of the water systems required. Related land developments provide for recreation, fish and wildlife, drainage, and irrigation. Table 75 presents the physical features of this component of the total framework plan for the subbasin.

Water storage facilities would be provided having an aggregate storage capability of about 6.6 million acre-feet. Of this storage capability, 5,264,000 acre-feet would be in multiple-purpose reservoirs and 1,298,000 acre-feet would be in relatively small single-purpose impoundments for recreation and related fish and wildlife purposes.

Multiple-purpose storage would be provided in 552 reservoirs, of which 39 would have individual storage capacities greater than 25,000 acre-feet and 513 would have individual capacities of less than that amount. Of the multiple-purpose storage of 5,264,000 acre-feet, 1,869,000 acre-feet would be inactive storage, 763,000

Oxbows Created By Channel Cut-Offs Can Be Used For Water-Related Recreation

Table 75 – WATER CONTROL AND RELATED LAND DEVELOPMENT, FRAMEWORK PLAN
MIDDLE MISSOURI SUBBASIN

Feature	Unit	Amounts 1980	2000	2020
		(Cumulative Above Current)		
SURFACE WATER CONTROL				
Storage	1,000 AF	2,666	4,242	6,562
Local Protection	Miles	146	362	727
Bank Stabilization	Miles	325	973	1,298
Grade Stabilization	Structures	1,706	4,418	6,688
LAND DEVELOPMENT				
Recreation, Fish and Wildlife	1,000 AC	71	114	181
Group Drainage	1,000 AC	29	134	194
Surface Water Irrigation				
Federal	1,000 AC	0	0	27
Non-Federal	1,000 AC	21	91	322
Public Land Conservation	1,000 AC	0	2	2

acre-feet would be conservation or joint use storage, and 2,632,000 acre-feet would be for flood control. The conservation storage would be used as follows:

Streamflow Augmentation,	
Quality	74,000 acre-feet
Irrigation	416,000 "
Recreation, Fish & Wildlife	382,000 "
Flood Control	Incidental benefits from regulation

Extensive channel improvements would also be provided for local flood protection, approximating 727 miles of improvements by 2020. Local flood protection would be provided by 22 miles of improvements to Ida Grove (built), Exira, Atlantic, Hastings, and Hamburg in Iowa, and to Walthill, Nebr., Sherman Field (Leavenworth), Kans., and Rockport, Mo., and 556 miles would be associated with watershed improvements. The remaining 149 miles are designated for agricultural levees along the Missouri River downstream from Omaha, Nebr. Bank stabilization structures would cover about 1,300 miles of stream and about 6,700 individual structures would be provided for gully control.

Related land developments include 181,000 acres of land to be developed for recreation and fish and wildlife purposes; drainage of 194,000 acres by group systems; and the development of 349,000 acres of irrigated land using surface-water supplies. Land conservation practices would also be applied to 2,000 acres of federally owned lands.

Environmental Enhancement and Non-Structural Measures

Environmental enhancement and non-structural measures included as a part of the subbasin framework plan include sufficient water and sewage treatment facilities to meet future needs; the development and management of 83,000 acres of land for wildlife purposes; development of three fish hatcheries and impoundments; and the development of two special use recreation areas and 375 miles of trails. Non-structural measures are limited to the preparation of 114 flood hazard reports covering 813,000 acres for flood plain management purposes. Table 76 summarizes the

Table 76 – ENVIRONMENTAL ENHANCEMENT AND NON-STRUCTURAL MEASURES
FRAMEWORK PLAN – MIDDLE MISSOURI SUBBASIN

Feature	Unit	Amounts 1980	2000	2020
		(Cumulative Above Current)		
ENVIRONMENTAL				
Sewage Treatment Plants[1]	Number	300	310	400
Water Supply and Treatment	1,000 AF/YR	125	227	373
Fish and Wildlife				
Management Areas	1,000 AC	59	83	83
Fish Hatcheries	Number	1	2	2
Fish Impoundments	Number	1	1	1
Special Areas	Number	1	2	2
Trails	Miles	0	225	375
NON-STRUCTURAL				
Flood Plain Management				
Area	1,000 AC	93	653	813
Flood Hazard Reports	Number	22	74	114

[1] Includes existing plants.

environmental and non-structural features of the subbasin framework plan.

Land and Water Changes

Net land use changes that would result from the total subbasin framework plan are shown in table 77.

Water supply studies indicate a streamflow depletion of about 2.4 million acre-feet and a ground-water depletion of 137,000 acre-feet. Ground-water depletions were estimated to approximate 10 percent of withdrawals and reflect a recognition that some outlying areas do not possess full recharge capability. Table 78 presents the withdrawals and consumptive uses of water for the various purposes of the subbasin framework plan.

Table 77 – LAND USE CHANGES, FRAMEWORK PLAN
MIDDLE MISSOURI SUBBASIN

Principal Use	Net Land Use Changes			
	1965-1980	1980-2000	2000-2020	1965-2020
	(Thousand Acres)			
Irrigated Cropland	+237	+605	+ 784	+1,626
Non-irrigated Cropland	- 421	- 788	- 1,121	- 2,330
Forest and Woodland	- 40	- 44	- 37	- 121
Pasture and Range	- 114	- 113	- 95	- 322
Transportation, Urban, & Built-up	+ 69	+136	+ 221	+ 426
Other (Rec. F&WL & Other Uses)	+157	+117	+ 150	+ 424
Water	+112	+ 87	+ 98	+ 297

Table 78 – WATER WITHDRAWALS, DEPLETIONS, AND OTHER CHANGES
FRAMEWORK PLAN – MIDDLE MISSOURI SUBBASIN

Service	Withdrawals						Depletions					
	Ground			Surface			Ground			Surface		
	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
	(Cumulative Above Current – Thousand Acre-feet/Year)											
Irrigation	217	755	1,282	23	91	443	22	76	128	218	770	1,527
M&I, Rural Domestic	16	29	48	109	198	325	2	3	5	22	40	65
Thermal Power				273	560	757				14	54	84
Livestock	10	22	41	26	56	95	1	2	4	35	76	132
Land Conservation				47	142	238				47	142	238
Wetlands, Fish and Wildlife				27	41	41				27	41	41
Evaporation				118	212	335				118	212	335
Total	243	806	1,371	623	1,300	2,234	25	81	137	481	1,335	2,422

Costs

Estimates of first costs and annual operation, maintenance, and replacement costs were prepared as shown in figure 39. The total investment requirement approximates $2.2 billion, with $589 million and $1.4 billion at the 1980 and 2000 bench-mark years, respectively. Annual operation, maintenance, and replacement costs would range from $17.5 million by 1980 to $74 million by 2020.

First costs were also distributed to each functional feature of the subbasin framework plan and are shown graphically in figure 40. Of the total investment, the largest share, $522 million, or 24 percent, would be for recreation, followed by irrigation, land conservation, and flood control with requirements approximating 18, 15, and 10 percent of the total, respectively.

In order to reflect the cost-sharing relationships of the subbasin framework plan, first costs were further disaggregated to reflect existing legal and policy considerations. In this subbasin, the initial Federal investment would be about $651.5 million, of which $97.3 million would have to be reimbursed by non-Federal interests over the long term and $49.4 million would be required to meet initial cost-sharing requirements. Similarly, non-Federal programs would have an initial first cost of $1,469.4 million, of which $408.5 million could be borne by Federal grant and assistance programs, giving a net non-Federal investment of $1,060.9 million. On the basis of initial investments, costs would be borne 49 percent by the Federal government and 51 percent by non-Federal interests. On the basis of net costs, the relationship would be 44 percent Federal and 56 percent non-Federal. Distributed costs together with cost-sharing requirements are shown on table 79.

Table 79 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY – MIDDLE MISSOURI SUBBASIN

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						256.4		256.4
State & Local Recreation						206.3	82.6	123.7
National Recreation Area								
Private Land Conservation						328.0	164.0	164.0
Irrigation Rehabilitation								
Access						1.1		1.1
Refuges	2.4	2.4						
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	48.7	38.9			9.8			
Other Single Purpose Res.						135.6		135.6
Grade Stabilization	142.9	114.3			28.6			
Bank Stabilization	25.7	18.0			7.7			
M. P. Reservoirs	450.3	(320.7)	(129.6)	(76.7)				
Water Quality			25.2					
Irrigation			42.2	42.2				
M & I								
Power								
Recreation		146.3	31.1	34.5				
Fish and Wildlife			31.1					
Flood Control		174.4						
Surface Water Irrigation	20.6	20.6		20.6		64.5		64.5
Group Drainage	4.0	2.0			2.0			
Public Land Conservation	.1	.1						
Environ. and Non-Structural								
Sewage Treatment						131.0	39.3	91.7
Water Supply & Treatment						219.8	109.9	109.9
Fish and Wildlife								
Wetlands								
Management Areas						25.3	12.7	12.6
Fish Hatcheries	2.4	1.2			1.2			
Fish Impoundments	.2	.1			.1			
Scenic Rivers								
Trails	1.6	1.6						
Flood Plain Management	2.0	2.0				101.4		101.4
Forest Management								
Precip. Management								
Totals	700.9	521.9	129.6	97.3	49.4	1,469.4	408.5	1,060.9
	1965-2020 Total: 2,170.3							

Table 80 – FRAMEWORK PLAN FOR 1980 – MIDDLE MISSOURI SUBBASIN

Plan Feature	Description and Purpose	Initial First Costs			Annual Operation, Maintenance and Replacement Costs		
		Federal	Non-Fed	Total	Federal	Non-Fed	Total
		($ Million)			($ Thousand)		
Storage Reservoirs							
Single-purpose Impoundments	Recreation reservoirs with 373,000 acre-feet of storage.	0	42.1	42.1	0	178	178
Multiple-Purpose Impoundments, Major and Minor	21 impoundments having 1,699,000 acre-feet of storage and 205 minor reservoirs with a capacity of 594,000 acre-feet for water quality, irrigation, recreation, fish & wildlife, and flood control.	165.5	0	165.5	1,106	614	1,720
Irrigation							
New Systems	Provide 239,000 acres of irrigation subbasin-wide.	0	47.8	47.8	0	2,392	2,392
Group Drainage	Provide 29,000 acres of public or group drainage.	0.1	0.1	0.2	0	5	5
Local Flood Protection	Channel and levee improvements involving 146 miles for protection of Ida Grove (built), Exira, Atlantic, and Hastings, Iowa and Sherman Field (Leavenworth), Kans., agricultural lands, and both urban and agricultural areas associated with watershed improvements.	10.8	2.7	13.5	0	252	252
Grade Stabilization	1,706 grade stabilization structures for erosion control.	24.9	6.2	31.1	0	155	155
Bank Stabilization	Bank protection on the Little Sioux, Nishnabotna, and Boyer rivers covering 325 miles.	4.5	1.9	6.4	0	64	64
Recreation	The development of 89,000 acres by the State, local, and private sector and providing 48 new access sites to existing water.	16.0	24.8	40.8	0	1,238	1,238
Fish and Wildlife	59,000 acres for game management, 3 refuge additions, one new fish hatchery, and one fish impoundment.	11.9	9.5	21.4	13	125	138
Water Supply and Treatment	Treatment facilities to serve 229,000 people and development of individual supplies.	37.3	37.3	74.6	0	7,300	7,300
Sewage Treatment	Enlargement of 118 secondary facilities, additions to 22 secondary facilities, and construction of 160 new secondary facilities.	15.0	35.0	50.0	0	1,995	1,995
Land Conservation	Land treatment measures for 1,491,000 acres of private land.	38.5	38.5	77.0	0	2,000	2,000
Flood Plain Management	Preparation of 22 flood hazard reports covering 93,000 acres of flood plains.	0.4	18.0	18.4	10	90	100
Total		324.9	263.9	588.8	1,129	16,408	17,537

FIGURE 41

MIDDLE MISSOURI SUBBASIN

PRINCIPAL WATER CONTROL FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

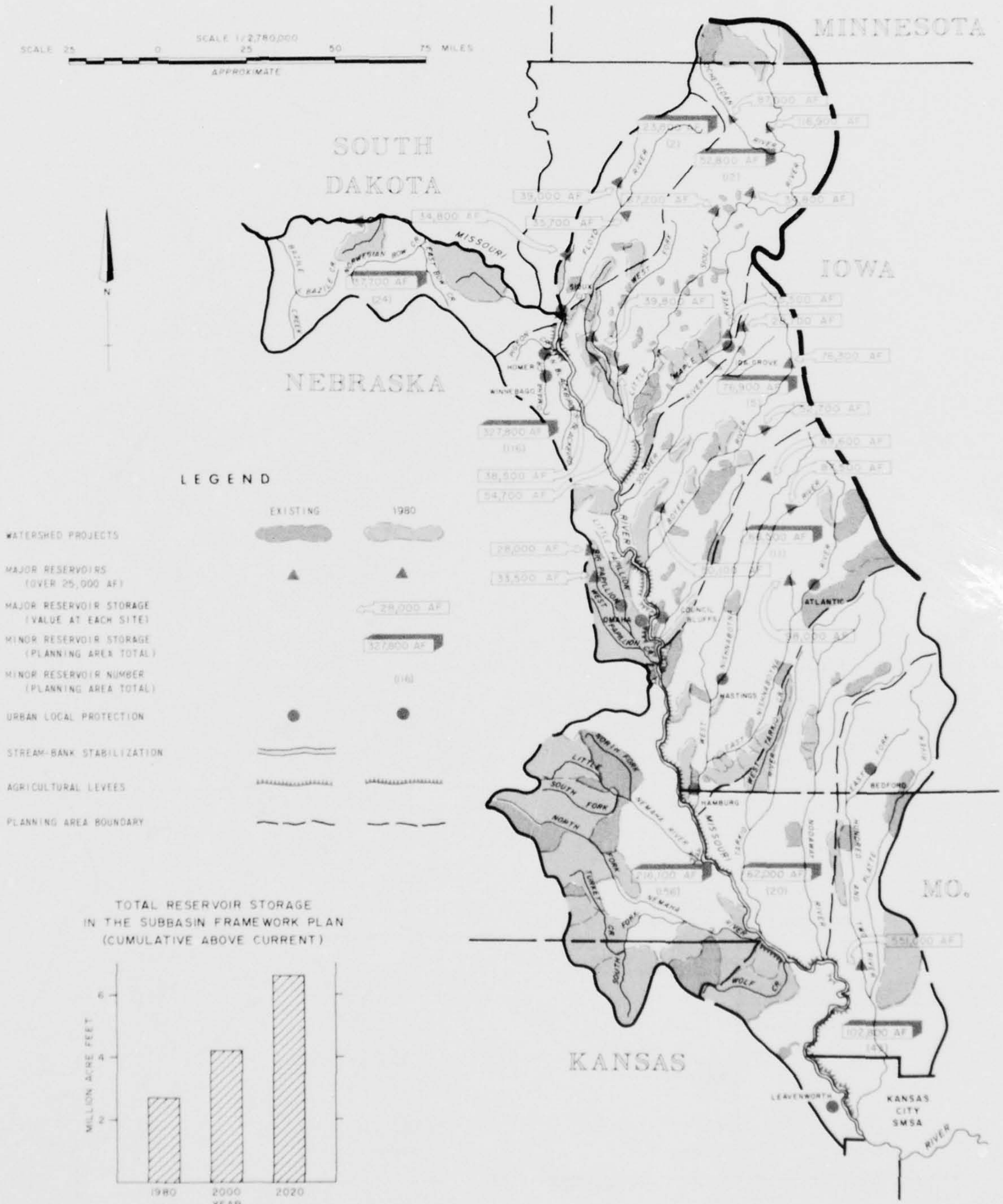


FIGURE 42

MIDDLE MISSOURI SUBBASIN

RELATED LAND DEVELOPMENT FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

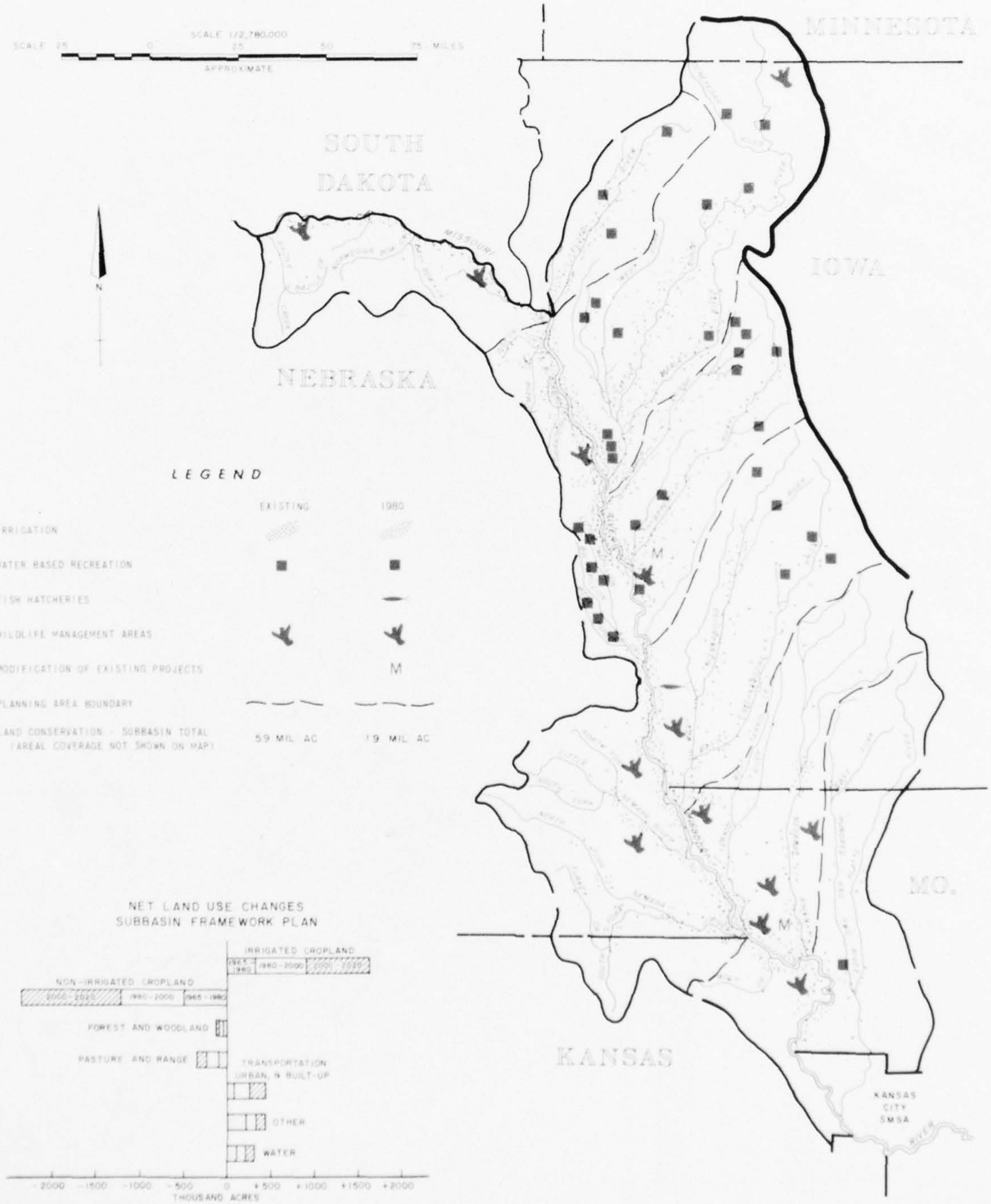
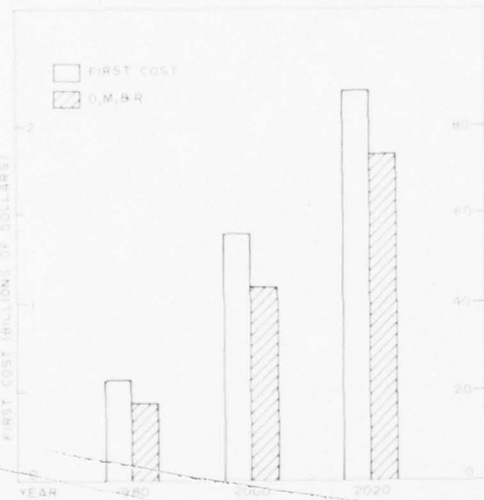


FIGURE 39
ESTIMATED FIRST COSTS AND
ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENTS
FRAMEWORK PLAN
MIDDLE MISSOURI SUBBASIN
(cumulative above current)

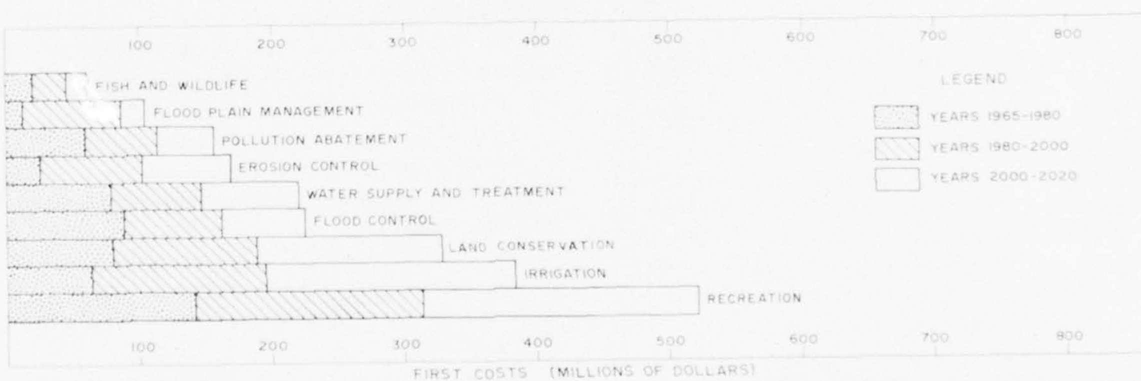


Levee Protection Along The Missouri River
Is Still Required

Short-Range Framework Plan

The short-range (1980) features of the subbasin framework plan are summarized in table 80. Figures 41 and 42 show the major features of the 1980 framework plan by geographical location.

FIGURE 40
DISTRIBUTION OF COSTS BY FUNCTIONAL PURPOSES
FRAMEWORK PLAN
MIDDLE MISSOURI SUBBASIN



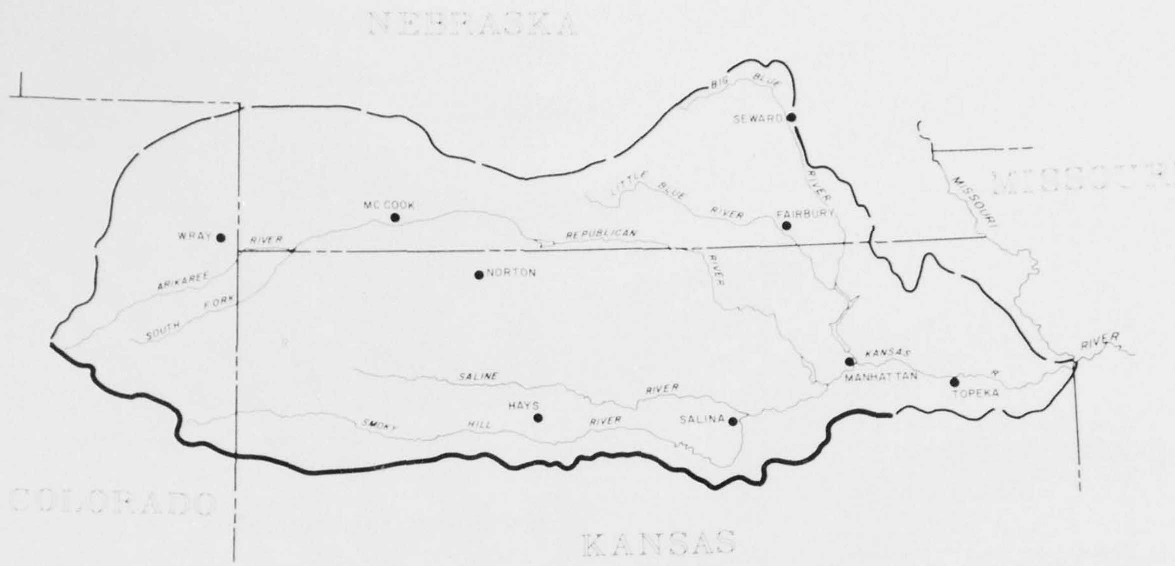
KANSAS SUBBASIN

The Kansas Subbasin, located along the southern edge of the basin, contains a total area of about 60,700 square miles. It is oblong, drains from west to east, and has a length of about 500 miles and a width of about 220 miles. Approximately 96 percent of the area is private agriculture land, of which about 60 percent is cropland. The more important metropolitan centers are Topeka, Salina, and Lawrence, Kans. A part of the Kansas City metropolitan area is located in the planning area. However, for planning purposes, the entire Kansas City area was considered with the Lower Missouri Subbasin.

Water Resources

The mean annual runoff ranges from approximately 0.25 of an inch in the western portion of the subbasin to 8 inches in the eastern part. The normal annual precipitation ranges from a high of about 35 inches at the mouth of the Kansas River to a low of about 16 inches in the dry western tip of the subbasin. Droughts, tornadoes, hot winds, dust storms, hail, and intense rainstorms commonly occur over much of the subbasin.

Ground water is a major source of water supply for agriculture, municipalities, and industries. The western portion of the basin, even though it has more ground water in storage than the eastern portion, has less natural



recharge because of low precipitation and relatively high water loss from evapotranspiration. However, the largest ground-water aquifers are concentrated in the western and north-central portions of the basin, particularly the drainage areas of the upper portions of the Smoky Hill, Solomon, Saline, and Republican river basins, which have in excess of 175 *million* acre-feet of ground water in storage. The yield which can be obtained from wells in the area is highly variable, ranging from near zero in limited portions to over 1,500 gallons per minute in some areas. The depth to water also varies considerably, but over the larger portion of the area, water levels are 50 to 150 feet below the land surface.

Another major unconsolidated aquifer is found in the Big Blue River Basin in Nebraska. The ground water in storage is estimated to be 200 million acre-feet. Generally, the depth to water below land surface ranges from 50 to 200 feet, and wells that penetrate more than 40 feet of saturated sand and gravel will yield from about 400 to as much as 2,000 gallons per minute. Water levels are declining in certain localities where large amounts of water are withdrawn for irrigation. In time, such ground water mining will exhaust the aquifer's storage.

The alluvium in the valleys of many of the larger streams consists of unconsolidated deposits of sand and gravel which are quite permeable and yield water to wells in excess of 1,000 gallons per minute in some areas; however, in areas where these deposits consist of a heterogeneous mixture of finer plastics, well yields are much lower. The saturated thickness and the quantity of water in storage in these alluvial deposits are not great in comparison with that of the major aquifers in the western part of the basin. These floodplain deposits probably contain in excess of 6 million acre-feet of water. The major river valleys with substantial yield capacities include the Kansas, Big and Little Blue, Republican, Smoky Hill, Saline, and Solomon rivers.

In 1965 there were 408 municipalities in the subbasin, and 348 provided public water systems serving about two-thirds of the 1960 population. There were 231 public sewerage systems. Of these, 198 provided secondary treatment, 30 provided primary treatment, and only 3 provided *no treatment* of wastes. These systems reduced waste loads to the streams of the subbasin by about 55 percent, from 1.2 million to about 0.6 million population equivalents.

Most of the industrial organic wastes are treated by the municipal waste treatment plants, but even so large quantities of industrial wastes are discharged without adequate treatment.

About 19,000 acre-feet of water are diverted for cooling at thermal power generation stations. No thermal problems exist since most power plants employ cooling towers.

There have been pollution problems resulting from industrial spills and improperly handled wastes. Wastes from oil and gas fields are under strict surveillance. Oil field wastes in this area are exceptionally high in chlorides and sulfates. Other pollutants in order of importance are livestock wastes, silt, nutrients, and pesticides, all of which are associated with recently developed animal feedlot operations and from land surface drainage during periods of rainfall. One of the most severe problems in many areas of the Missouri River Basin is the surface runoff from livestock feeding operations. The State of Kansas has enacted legislation to reduce and control existing waste loadings to the streams from livestock feeder operations.

The dissolved solids concentration in the streamflow leaving the subbasin averages about 390 mg/l. There are

many locations within the subbasin where the concentration is much higher and creates a problem in use of the water. This is mainly from salt outcrops. Reservoir storage regulation has made some quality improvement in the lower Republican, Smoky Hill, and Kansas rivers. The dissolved solids concentration of the streamflow leaving the subbasin is influenced by the return flows from 1,703,000 acres of irrigation and municipal, mining, and industrial uses.

Pollution affecting fisheries exists along approximately 300 miles of streams. Irrigation dewatering is a problem along 165 miles. Industrial and agricultural pollution also degrades the streams. Completion of several large multi-purpose dams in the lower Kansas River subbasin will significantly reduce the suspended sediment level of the Kansas River. Management and operation of these reservoirs can be an important contribution to improving fisheries in future years.

Flood and Erosion Control

The existing flood and erosion control projects are summarized in table 81. With the exception of the reservoirs and watershed projects, these improvements are primarily single-purpose in character.

Table 81 – EXISTING FLOOD AND EROSION CONTROL PROJECTS – KANSAS SUBBASIN

Type	No.	Levees & Channels	Total Storage	Area Protected	Annual Damages Prevented
		(Miles)	(1,000 AF)	(1,000 AC)	($1,000)
Major Reservoirs	17		8,729	742	36,200[1]
Upstream Watershed Projects	28			124	1,720
Flood Retarding	424		240		
Grade Stabilization	111	100			
Levees and Channels	14	185		37	9,850

[1] Includes damages prevented in the Lower Missouri Subbasin.

Topeka, Kansas Is Protected From Flooding By This Project

There are approximately 2,462,000 acres of flood plain lands in the subbasin, of which about 742,000 acres, or 30 percent, are protected to some degree by one or more of 18 major flood control reservoirs. The reservoirs essentially eliminate flooding in areas just below their respective dams, but are progressively less effective downstream due to the flood-producing capability of intervening drainage areas. Local flood control projects at Salina, Manhattan, Topeka, and Lawrence, Kans., operate in conjunction with upstream reservoirs to provide a high degree of protection to about 32,000 acres of highly developed urban areas. In addition, 38 other projects provide varying degrees of protection to 129,000 acres of flood plain lands along other streams, including several urban communities. These range from single-purpose local flood protection projects to watershed projects which may be multiple-purpose in nature but are relatively local in scope. Local interests have constructed many levees, channel improvements, and small reservoirs which provide varying degrees of flood protection to limited areas.

In the absence of existing projects, the average annual flood damage would amount to $30,389,000. The capability of existing projects reduces the residual damage to $19,631,000, which is a reduction in flood damages of 35 percent under current conditions. Because the larger cities and many smaller communities with severe flood damage potential presently enjoy a high degree of protection, the damage in urban areas accounts for only about 6 percent of the total residual damage.

Streambank erosion is extensive in the subbasin, but the rates of erosion are moderate to mild, with about 530 bank-miles, or one percent of the existing channel banks, receiving serious erosion. Average annual losses due to streambank erosion are estimated to be $1,287,000. The most severe problem at present is along the Kansas River, where there are about 50 miles of actively eroding streambank.

Streambank Erosion Is Extensive

Gully erosion and channel degrading account for most of the land damage in the subbasin, and land values are high enough, in many cases, to justify structural treatment. Many local areas have significant gully erosion problems which are not of a size and severity to justify project action. Treatment of such problems is accomplished by individual owners with Federal technical and cost-sharing assistance. About 3,400 acres are damaged each year by voiding and depreciation of gullies severe enough to consider project-type action. The average annual damages are estimated to be $1,075,000.

Water Supply

Agriculture is by far the largest user of water in the subbasin, primarily for irrigation, and to a much lesser extent, livestock uses. Of the estimated 2.8 million acre-feet used annually in 1965 for irrigation and livestock, some 85 percent was from ground-water sources. Other uses such as municipal-industrial, separate industrial, mineral, and rural domestic, are also supplied primarily from ground water. Only cooling water for power generation plants has its largest portion supplied by surface water.

Municipal and industrial water demands were estimated to have amounted to 72,000 acre-feet annually, in 1965. Approximately two-thirds of this was supplied by ground water. Rural domestic water demands currently average 36,000 acre-feet annually, of which over 90 percent is from ground water.

Separate industrial demands amount to 38,000 acre-feet annually, 80 percent supplied by ground water. While food production and processing are important in this wheat, feed grain, and livestock producing subregion, they do not require large amounts of water.

The mineral industry – oil, gas, and coal production, and sand and gravel operations – uses an average of 9,000 acre-feet of water, 89 percent of this supplied from ground water. Thermal power plants currently use some 19,000 acre-feet annually for cooling purposes.

Currently, 54,000 acre-feet of water are required annually for the 2.7 million head of cattle, 1.2 million head of swine, 390,000 head of sheep, and poultry in the subbasin.

Electric Power Generation

It is estimated that in 1965 the subbasin required about 4.2 billion kwh of electric power. To meet this requirement, approximately 3 billion kwh were generated within the subbasin and the remainder supplied by imports. Thermal-electric plants account for over 99 percent of the subbasin's generation. The annual condenser cooling water requirement is estimated to be 368 thousand acre-feet. However, the cooling water consumption is estimated to be only 5 thousand acre-feet.

Fish, Wildlife, and Recreation

Practically all of the 337,000 acres of water area in the subbasin is valuable to fish and wildlife. The 33,100 acres of water and wetlands primarily devoted to fish and wildlife uses are in public ownership. Water consumptively used as single-purpose for fish and wildlife totals about 14,370 acre-feet.

Excess fishing opportunity is rapidly diminishing as demands for fishing increase. Although some reservoirs and streams offer good quality fishing, much of the fishing is of mediocre to fair quality. There are nine reservoirs, having 72,990 surface acres, that are considered Class 2 (statewide importance). A total of 148,790 acres of reservoirs and ponds provides the bulk of the subbasin's fishing capacity. There are no natural lakes in the Kansas River Subbasin. The estimated demand for fishing is roughly 82 percent of the present capacity. However, actual use is only 46 percent of the capacity because of the poor distribution of fishing opportunity.

Good hunting opportunities are provided in numerous areas. Deer are somewhat under-utilized since Kansas has only recently legalized deer hunting. Small game provides the bulk of the hunting. In some areas, pheasants and quail populations provide very good hunting. Waterfowl provide moderate amounts of hunting opportunity. The present demand of 2,436,000 hunter-days is roughly 29 percent greater than the present capacity of 1,874,000 hunter-days. The present

use of 1,374,000 hunter-days approaches the resources' capacity to supply "good" quality sport hunting.

A number of Federal reservoirs located on major river systems in the southeastern, central, and northwestern portions of the subbasin offer a seeming abundance, though unbalanced, distribution of water-oriented recreation opportunity, while the prairie landscape is highlighted by the presence of many historic and archeologic sites that testify to the early-day pioneer and Indian history of the area. Military outposts, museums, and the remains of Indian cultures combine with famous emigrant, cattle, and Pony Express trails to intrigue the unhurried vacationer and traveler.

Sailboating Illustrates A Recreational Use On Reservoirs In The Plains Area

State and locally administered recreation areas receive the heaviest use and account for about 44 percent of the total recreation land and water. A large proportion of State facilities, including parks and recreation areas, special use areas, and fishing and hunting areas, are located at and include project lands associated with Federal reservoirs. Local parks are very important to residents of the subbasin and support intensive use, although they furnish a relatively small amount of developed and undeveloped land.

Residents account for about 76 percent of the total calculated recreation demand. Most tourists pass through the area rather quickly and have a limited effect on the recreational resources. However, "nearby nonresidents" create a considerable impact on the eastern end of the subbasin in both Kansas and Nebraska. The 1965 calculated demand in activity-days for eight of the primary recreation activities is estimated to be 34 million activity-days.

Available information shows that there are moderate to moderately severe shortages of quality camping, sightseeing, nature study, boating, and picnicking facilities and opportunities in some areas. Relatively minor shortages exist for swimming, hiking and riding, and other facilities and opportunities. The eastern parts of the subbasin, especially the northeastern quarter, represent the areas of greatest current need. The Blue River drainage in Nebraska is especially short on water-based opportunities. Lesser areas of shortage

include other population centers and zones bordering major highways.

Land Conservation and Drainage

Currently 22.3 million acres of the privately owned lands in the subbasin are used for crop production, 13.6 million acres are used for pasture and range, 597 thousand acres are in forest and woodlands, 552 thousand acres are in other agricultural uses, and one thousand acres are in nonagricultural uses. About 1.7 million acres of cropland are irrigated annually. Approximately 69 thousand acres of Federal land are used for agricultural purposes, 49 thousand are grazed, and 20 thousand produce forest products. An additional 213 thousand acres of Federal land are used for non-agricultural purposes.

Of the 22.3 million acres used for cropland, 19.9 million acres, or 89 percent, are suitable for sustained cultivation with proper management and conservation measures. The remaining 2.5 million acres of cropland are not suitable for continuous cultivation without sustaining damage to the soil resources. Conversely, about 900 thousand acres of pasture and range are physically suitable and can be used for sustained crop production with proper management and conservation measures.

Wind and water erosion seriously affect lands in the subbasin. Through their own efforts and with Federal technical assistance and cost-sharing available to them, the owners and operators have installed adequate conservation treatment and management on 14.3 million acres of the private agricultural lands. Management-type practices on 12.9 million acres and mechanical or vegetative-type practices on 11 million acres are needed to provide adequate levels of conservation treatment and management.

On federally owned lands, 138 thousand acres, or 49 percent, are currently adequately treated and managed. The remaining 144 thousand acres in the subbasin need improved conservation treatment and management for sustained use without deterioration.

There are approximately 1.3 million acres of agricultural land in the subbasin subject to excess water problems. Currently, 442 thousand acres of cropland have been provided with adequate drainage. Of the remaining 881 thousand acres of land subject to excess water, 306 thousand acres are considered potentially suitable and feasible to drain. About 40 percent of this area is currently cultivated and current use would be improved by allowing timely operations. An additional 151 thousand acres of pasture and range and 32 thousand acres of forest and woodland are subject to problems of excess water and are suitable for conversion to cultivated uses. Approximately 142,000 acres will require project-type measures to remove excess water.

About 541 thousand acres, or 42 percent, of the land with excess water problems are considered infeasible to drain. Of this total, 101 thousand acres are currently used for cropland and should be converted to noncrop uses. This and the remainder should be used for grazing and woodlands and managed to utilize its natural value as wildlife habitat.

Planning Objectives

As with all subbasins within the region, much of the produce of the subbasin is sold outside and a large part of its purchases are made from outside of the area. The future economy will be shaped in a large part by developments in technology and expanded market outlets.

The current economy, largely agriculturally based, is in a period of transition. Expansion and growth can be measured by increasing population, urbanization, industrialization, and productivity. Although relatively less important than 2 decades ago, agriculture continues to contribute a large share of the wealth and income, as well as contributing directly to the growth of related agricultural business in the subbasin.

Considerable development of land and water resources, most of which is multiple-purpose, has already taken place in the subbasin. Storage capacity in reservoirs approximates 9 million acre-feet, lands irrigated total 1.7 million acres, and flood protection is available to over 800,000 acres. In view of the extensive water resource development that has taken place, formulation of a framework plan for this area is based on existing projects forming the nucleus of the future program that must relate to the developments in place. Generally, further control and development would be aimed at supplying the expanding water needs of urban communities, further control of high flows, extensive use of ground water for irrigation (especially in the western portion of the subbasin), the regulation and use of surface water in some areas to assist in stabilizing ground-water levels and sustaining and enhancing irrigation, and such environmental enhancements needed to assure good water quality and recreational opportunities to the residents of the area.

The primary goals for planning, therefore, are to support the water and land needs in relation to the expanding urban-industrial requirements, further intensification of the agricultural production of the rural areas, and enhancement of the environmental characteristics of the subbasin. There are limited alternatives to meet these goals. Alternatives generally concern relationships of various reservoir systems that affect water availability for the systems to operate effectively. These were considered during plan formulation, and screening techniques were used to develop systems that can be operated for the intended purposes.

Specified Non-Federal Programs and Modifications of Existing Developments

As of 1965, about 1,449,000 acres were irrigated from ground-water sources. Over the projection period (thru 2020), irrigation from the same source by the private sector is anticipated to provide an additional 1,898,000 acres of irrigated land, though 264,000 acres of presently irrigated land may be converted to gravity service under the trans-basin diversion potential as discussed later. As in the other subbasins, recreational development by the State, local, and private sectors is projected at rates to meet indicated demands, and land conservation programs will continue at about the same rate as in the past. By 2000, improvements to existing irrigation systems should be started as an economic efficiency consideration. In the near future, 162,000 acre-feet of flood storage in Kanopolis Reservoir on the Smoky Hill River should be reallocated to meet municipal, industrial, and irrigation requirements. This would require a modification of the outlet works. Additional access to existing developments can also add to the recreational opportunities of the subbasin. These features of the subbasin framework plan are summarized in table 82.

Table 82 – SPECIFIED NON-FEDERAL PROGRAMS AND MODIFICATIONS OF EXISTING DEVELOPMENTS, FRAMEWORK PLAN – KANSAS SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SPECIFIED NON-FEDERAL PROGRAMS				
Private Ground-water Irrigation	1,000 AC	650	1,084	1,898
State, Local, and Private Recreation	1,000 AC	91	160	244
Private Land Conservation	1,000 AC	5,035	10,700	15,308
MODIFICATION OF EXISTING DEVELOPMENTS				
Irrigation System Improvements				
Ditch Consolidation	Miles	0	0	2
Ditch Lining	Miles	0	393	789
Drainage	1,000 AC	0	4	5
Reservoirs	1,000 AF	162	162	162
Fishing & Recreation Access	Number	35	60	75
Refuge Additions	Number	2	4	6

Water Control and Related Land Development

Water and related land development features of the subbasin framework plan were formulated in response to the objectives and conditions previously outlined. These features are summarized in table 83.

The surface water control features of the total subbasin framework plan include 1,258 multiple-purpose reservoirs providing a total storage capacity of 6,341,000 acre-feet. Of this amount, 4,293,000 acre-feet would be developed in 15 reservoirs having individual storage capacities greater than 25,000 acre-feet, and 2,048,000

Table 83 – WATER CONTROL AND RELATED LAND DEVELOPMENT, FRAMEWORK PLAN KANSAS SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SURFACE WATER CONTROL				
Storage[1]	1,000 AF	2,334	4,454	6,478
Local Protection	Miles	79	288	380
Bank Stabilization	Miles	71	211	282
Grade Stabilization	Structures	218	249	332
LAND DEVELOPMENT				
Recreation, Fish and Wildlife	1,000 AC	75	164	255
Group Drainage	1,000 AC	9	31	36
Surface Water Irrigation[2]				
Federal	1,000 AC	67	170	232
Non-Federal	1,000 AC	13	40	87
Public Land Conservation	1,000 AC	18	63	91

[1]Includes 500,000 acre-feet of storage from the potential transbasin diversion from the Platte-Niobrara Subbasin to the Kansas Subbasin.

[2]Excludes 264,000 acres of land which would be converted from ground to surface water irrigation, and 66,000 acres of new irrigated land due to the potential import by transbasin diversion.

Kanopolis Dam and Reservoir Already Has Provided Benefits In Excess Of Its Cost

acre-feet would be provided in 1,243 reservoirs having individual storage capacities of less than 25,000 acre-feet. In addition to the multiple-purpose storage, 137,000 acre-feet of single-purpose storage could be provided — 113,000 acre-feet for general recreation and 24,000 acre-feet for fish and wildlife purposes.

Watershed Projects Are Needed Throughout The Subbasin

Of the 6,341,000 acre-feet in multiple-purpose impoundments, 640,000 acre-feet would be inactive storage, 1,609,000 acre-feet would be for joint beneficial uses, and 4,092,000 acre-feet would be for flood control. The joint use storage would be used as follows:

Streamflow Augmentation, Quality	414,000 acre-feet
Irrigation	947,000 "
Municipal & Industrial	156,000 "
Recreation, Fish & Wildlife	804,000 "
Flood Control	Incidental benefits from regulation

Channel and levee improvements covering 48 stream miles would be provided for local protection at Beatrice, York, Crete, DeWitt, and Superior in Nebraska; and Marysville, Paradise, Codell, Natoma, Gypsum, Hays, Keats, Atwood, Oberlin, Tescott, Ellis, Edwardsville, Rossville, Louisville, Muncie, and Herrington in Kansas, and 332 miles would be associated with watershed improvements. Other in-stream controls would consist of

282 miles of bank stabilization measures primarily located on the Smoky Hill and Kansas rivers, and of 332 grade stabilization structures.

Related land development features would include about 255,000 acres of land, associated generally with reservoirs, for recreation and fish and wildlife purposes; group system drainage facilities for 36,000 acres of agricultural land; and the irrigation from surface sources of about 319,000 acres of land. Land conservation practices on 91,000 acres of federally owned land would also be applied.

Environmental Enhancement and Non-Structural Measures

The additional environmental enhancements and non-structural measures reflect those features previously outlined for other subbasins. These are presented in table 84.

Table 84 – ENVIRONMENTAL ENHANCEMENT AND NON-STRUCTURAL MEASURES FRAMEWORK PLAN – KANSAS SUBBASIN

Feature	Unit	Amounts 1980	2000	2020
		(Cumulative Above Current)		
ENVIRONMENTAL				
Sewage Treatment Plants[1]	Number	350	375	700
Water Supply & Treatment	1,000 AF/YR	37	95	185
Fish and Wildlife				
Wetlands	1,000 AC	12	23	34
Management Areas	1,000 AC	13	59	112
Fish Hatcheries	Number	2	3	4
Special Areas	Number	8	15	15
Trails	Miles	275	450	750
NON-STRUCTURAL				
Flood Plain Management Area	1,000 AC	50	427	904
Flood Hazard Reports	Number	9	45	74

[1]Includes existing plants.

Land and Water Changes

Net land use changes that would result from the subbasin framework plan are shown in table 85. The conversions of land for various purposes reflect the same considerations described previously for other subbasins.

Water supply studies indicate a future streamflow depletion in the subbasin of about 0.9 million acre-feet. Ground-water depletions, on the other hand, are about 2.2 million acre-feet, or about 2½ times that of streamflow. *This illustrates the dependence on ground* waters for future beneficial uses in the Kansas Subbasin. Table 86 presents the withdrawals and consumptive uses of water.

The extensive future ground-water development, as envisioned in the subbasin framework plan, will result in the "mining" of ground water in many areas. Extensive ground-water withdrawals will also have an appreciable affect on stream flows. Streamflow depletions ranging from zero to 30 percent of ground-water withdrawals are anticipated in the various hydrologic planning areas of the subbasin.

In the western part of the subbasin, the ground-water table lies about 200 feet below the general upland surface. Ground water extracted in this area should have little discernible affect on streamflows, but "mining" of the water supply will take place and, when the supply is exhausted a considerable length of time would be required to replenish it from natural recharge.

In the uplands of the Blue River drainage, ground-water levels are generally below stream levels. Thus, recharge to the aquifers from streams is limited and areas of discharge from the aquifers are far distant from the recharge areas. Withdrawals of ground water, therefore,

Table 85 – LAND USE CHANGES, FRAMEWORK PLAN – KANSAS SUBBASIN

Principal Use	Net Land Use Changes 1965-1980	1980-2000	2000-2020	1965-2020
	(Thousand Acres)			
Irrigated	+722	+549	+ 909	+2,180
Non-irrigated Cropland	-820	-732	-1,083	-2,635
Forest and Woodland	- 30	- 5	- 16	- 51
Pasture and Range	-203	-220	- 254	- 677
Transportation, Urban, & Built-up	+ 76	+138	+ 200	+ 414
Other (Rec, F&WL, & Other Uses)	+187	+195	+ 179	+ 561
Water	+ 68	+ 75	+ 65	+ 208

Table 86 – WATER WITHDRAWALS, DEPLETIONS, AND OTHER CHANGES, FRAMEWORK PLAN – KANSAS SUBBASIN

Service	Withdrawals						Depletions					
	Ground			Surface			Ground			Surface		
	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
	(Cumulative Above Current – Thousand Acre-feet/Year)											
Irrigation	1,063	1,687	2,953	137	392	707	841	1,266	2,182	98	398	817
M&I, Rural Domestic	18	49	107	19	46	78	1	3	5	5	14	30
Thermal Power	2	8	13	-6	8	20	1	3	5	9	26	42
Livestock	17	40	74	8	16	26	12	26	43	13	30	57
Land Conservation				23	56	88				23	56	88
Wetlands, Fish & Wildlife				11	22	22				11	22	22
Evaporation				109	266	357				109	266	357
Imports				0	-190	-500				0	-190	-500
Total	1,100	1,784	3,147	301	616	798	855	1,298	2,235	268	622	913

would also "mine" the aquifers until ultimately they would no longer provide water in usable and economical amounts.

The subbasin framework contemplates an import of surplus water from the Platte-Niobrara Subbasin for direct use in irrigation and to firm up ground-water usage in the Kansas Subbasin in Nebraska. While only rough reconnaissance appraisals have been made, it is estimated that an average of 500,000 acre-feet per year of import water would become available. After conveyance and reservoir evaporation losses, this water would be adequate to provide a substitute surface water supply for 264,000 acres of land now irrigated from ground waters, and a new water supply for 66,000 acres of irrigable land, or a total of 330,000 acres. This would require reservoir storage facilities, a diversion dam, and conveyance canals in the subbasin of origin (Platte-Niobrara); and other canals, several regulating reservoirs, and lateral and drainage systems in the Kansas Subbasin. The diversions of surface waters from the Platte-Niobrara drainage would be as follows:

Year	Total Import	Evaporation and Conveyance Losses	Irrigation Farm Deliveries	Return Flows from Irrigation: Nonbeneficial Uses	Return Flows from Irrigation: Ground-water Recharge	Return Flows from Irrigation: Streamflow Accretions
	(Thousand Acre-feet)					
2000	190	56	134	10	23	24
2020	500	88	412	25	75	48

As will be noted, the benefits of this potential import of water would overcome the demands on already overdeveloped ground waters in a part of the Kansas Subbasin for 264,000 acres, continue the irrigation of these lands from surface waters, and finally contribute some 118,000 acre-feet of recharge to the ground-water reservoir and to streamflow accretions. The latter would help stabilize ground water and streamflow for irrigation and all other dependent uses.

Considering the complexities of the transbasin diversion potential and the lack of definitive data, no attempt has been made to develop individual component costs. Rather a package cost estimate of $500 million was felt to represent the probable cost of the storage, conveyance, and distribution and drainage works already mentioned, including 500,000 acre-feet of storage. This storage is not included in the multiple-purpose storage figures in table 83 or in the costs of multiple-purpose storage in table 87. Rather the package cost of $500 million including all types of works described has been included in "Public Irrigation" cost total of $599.3 million. When details of the transbasin diversion are studied, a part of this total cost will be assigned to other purposes including flood control, fish and wildlife, recreation, and possibly municipal and industrial water supply, with some sharing between Federal and non-Federal investments.

Costs

Estimates of first costs and of annual operation, maintenance, and replacement costs for all features of the subbasin framework plan are shown on figure 43. The total first cost would be about $3.3 billion, with investment requirements at the bench-mark years of 1980 and 2000 being $883 million and $2.3 billion, respectively. Annual operation, maintenance, and replacement costs would range from $25.6 million by 1980 to $94.5 million by 2020.

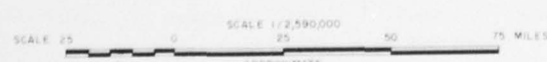
First costs were distributed to each functional feature of the subbasin framework plan as shown in figure 44. The largest share of the total would be for irrigation (32 percent), followed by land conservation (21 percent), water supply and treatment (13 percent), and flood control (12 percent).

A further disaggregation of first costs was made to determine the cost-sharing relationships of total investments. Based on existing legal and policy considerations, an initial Federal investment of $1,204.2 million would

Table 87 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY – KANSAS SUBBASIN

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						379.6		379.6
State & Local Recreation						331.3	132.6	198.7
National Recreation Area								
Private Land Conservation						687.0	343.5	343.5
Irrigation Rehabilitation	26.3	26.3		26.3				
Access						.3		.3
Refuges	2.7	2.7						
Hatcheries								
Reservoirs	3.3	3.3						
Water Control and Related Land								
Single Purpose F. C.	24.8	19.8			5.0			
Other Single Purpose Res.								
Grade Stabilization	12.0	9.6			2.4			
Bank Stabilization	9.5	6.7			2.8			
M. P. Reservoirs	521.0	(378.0)	(143.0)	(60.9)				
Water Quality			34.5					
Irrigation			36.6	36.6				
M & I			18.3	18.3				
Power								
Recreation		12.0	26.8	6.0				
Fish and Wildlife			26.8					
Flood Control		366.0						
Surface Water Irrigation	599.3	599.3		599.3		17.4		17.4
Group Drainage	3.7	1.9			1.8			
Public Land Conservation	.4	.4						
Environ. and Non-Structural								
Sewage Treatment						175.0	52.5	122.5
Water Supply & Treatment						400.2	200.1	200.1
Fish and Wildlife								
Wetlands	10.2	9.6			.6			
Management Areas						8.0	4.0	4.0
Fish Hatcheries	1.2	.7			.5			
Fish Impoundments								
Scenic Rivers								
Trails	1.6	1.6						
Flood Plain Management	1.3	1.3				107.8		107.8
Forest Management								
Precip. Management								
Totals	1,217.3	1,061.2	143.0	686.5	13.1	2,106.6	732.7	1,373.9

1965-2020 Total: 3,323.9



TOTAL RESERVOIR STORAGE
IN THE SUBBASIN FRAMEWORK PLAN
(CUMULATIVE ABOVE CURRENT)

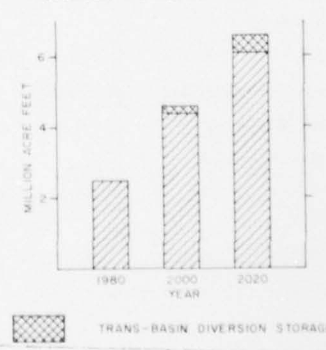


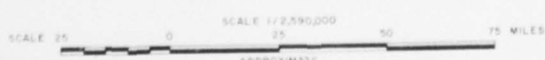
FIGURE 45

KANSAS SUBBASIN

PRINCIPAL WATER CONTROL FEATURES

EXISTING AND 1980 FRAMEWORK PLAN


N
NEBRASKA
COLORADO
RED
WILLOW
CREEK
MEDICINE
CREEK
FRENCHMAN
RIVER
REPUBLICAN
RIVER
N
FORK
REPUBLICAN
RIVER
CREEK
CREEK
ARIKAREE
RIVER
SOUTH
FORK
BEAVER
SAPPA
CREEK
DOG
PRAIRIE
NORTH
FORK
SOUTH
FORK
SALINE
RIVER
PARADISE
CR
BIG
CREEK
SMOKY
HILL
RIVER
LADDER
CREEK


SCALE 1/2,590,000
SCALE 25
0
25
50
75 MILES
APPROXIMATE

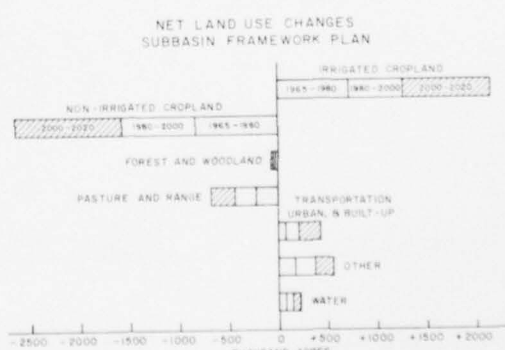

NET LAND USE CHANGES
SUBBASIN FRAMEWORK PLAN
IRRIGATED CROPLAND
1965 - 1980
1980 - 2000
2000 - 2020
NON - IRRIGATED CROPLAND
2000 - 2020
1980 - 2000
1965 - 1980
FOREST AND WOODLAND
PASTURE AND RANGE
TRANSPORTATION
URBAN, & BUILT-UP
OTHER
WATER
-2500
-2000
-1500
-1000
-500
0
+500
+1000
+1500
+2000
THOUSAND ACRES

FIGURE 46

KANSAS SUBBASIN

RELATED LAND DEVELOPMENT FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

AD-A043 941 MISSOURI BASIN INTER-AGENCY COMMITTEE F/G 8/6
COMPREHENSIVE FRAMEWORK STUDY MISSOURI RIVER BASIN. VOLUME 7. A--ETC(U)
JUN 69

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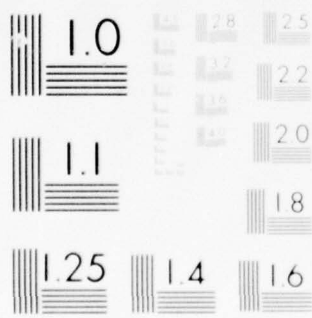
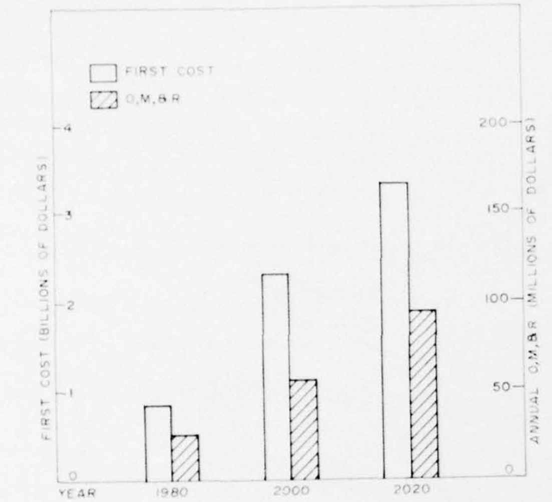


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Table 88 – FRAMEWORK PLAN FOR 1980 – KANSAS SUBBASIN

Plan Feature	Description and Purpose	Initial First Costs			Annual Operation, Maintenance and Replacement Costs		
		Federal	Non-Fed	Total	Federal	Non-Fed	Total
		($ Million)			($ Thousand)		
Storage Reservoir Modifications	Modification of outlet works and re-allocation of flood storage in Kanopolis Reservoir on the Smoky Hill River to meet municipal, industrial, and irrigation requirements.	3.3	0	3.3	0	75	75
Single-purpose Impoundments	Recreation and fish & wildlife reservoirs having 30,000 acre-feet of storage.	Costs are included in recreation and fish and wildlife items below.					
Multiple-purpose Impoundments, Major and Minor	Four impoundments having 1,260,000 acre-feet of storage and 735 minor reservoirs with a capacity of 1,044,000 acre-feet for water quality, irrigation, M&I, recreation, fish & wildlife, and flood control.	211.0	0	211.0	1,393	220	1,613
Irrigation New Systems	Provide 730,000 acres of irrigation subbasin-wide.	41.1	132.6	173.7	0	10,237	10,237
Group Drainage	Provide 9,000 acres of public or group drainage.	0.4	0.3	0.7	0	11	11
Local Flood Protection	Channel and levee improvements involving 79 miles for protection of Marysville, Paradise, Codell, Natoma, Gypsum, Hays, and Keats, Kans., and both urban and agricultural areas associated with watershed improvements.	8.3	2.1	10.4	0	33	33
Grade Stabilization	218 grade stabilization structures for erosion control.	7.0	1.8	8.8	0	26	26
Bank Stabilization	Bank protection on the Smoky Hill and Kansas rivers covering 71 miles.	1.7	0.7	2.4	0	24	24
Recreation	The development of 91,000 acres by the State, local, and private sector; providing 35 new access sites to existing water, and 275 miles of trails.	42.0	62.3	104.3	0	840	840
Fish and Wildlife	13,000 acres for game management, 12,000 acres of wetlands, 2 refuge additions, and 2 new fish hatcheries.	4.8	1.1	5.9	25	464	489
Water Supply and Treatment	Treatment facilities to serve 196,000 people and development of individual supplies.	53.3	53.3	106.6	0	5,575	5,575
Sewage Treatment	Enlargement of 198 secondary facilities, 30 additions to secondary facilities, and construction of 122 new secondary facilities.	15.6	36.4	52.0	0	1,551	1,551
Land Conservation	Land treatment measures for 5,035,000 acres of private land and 18,000 acres of federally owned land.	91.1	91.0	182.1	1	5,000	5,001
Flood Plain Management	Preparation of 9 flood hazard reports covering 50,000 acres of flood plains.	0.2	21.8	22.0	21	110	131
Total		479.8	403.4	883.2	1,440	24,166	25,606

FIGURE 43
ESTIMATED FIRST COSTS AND
ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENTS
FRAMEWORK PLAN
KANSAS SUBBASIN
(cumulative above current)

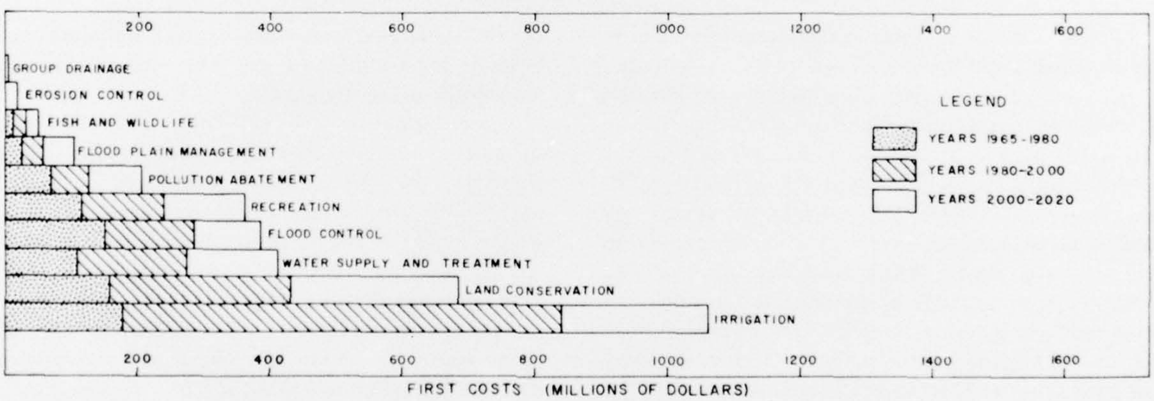


be required, of which $686.5 million would have to be reimbursed by local interests and these interests would provide $13.1 million for initial cost-sharing. Similarly, initial investments for non-Federal programs of $2,106.6 million could be netted to $1,373.9 million by Federal grant and assistance programs. On the basis of initial investments, the first costs would be shared 58 percent by the Federal Government and 42 percent by non-Federal sources. On the basis of net costs, the relationship would be 38 percent Federal and 62 percent non-Federal. Distributed costs together with cost-sharing requirements are shown in table 87.

Short-Range Framework Plan

The short-range (1980) framework plan features are summarized in table 88. The geographical locations of the major features of the framework plan are shown in figures 45 and 46.

FIGURE 44
DISTRIBUTION OF COSTS BY FUNCTIONAL PURPOSES
FRAMEWORK PLAN
KANSAS SUBBASIN

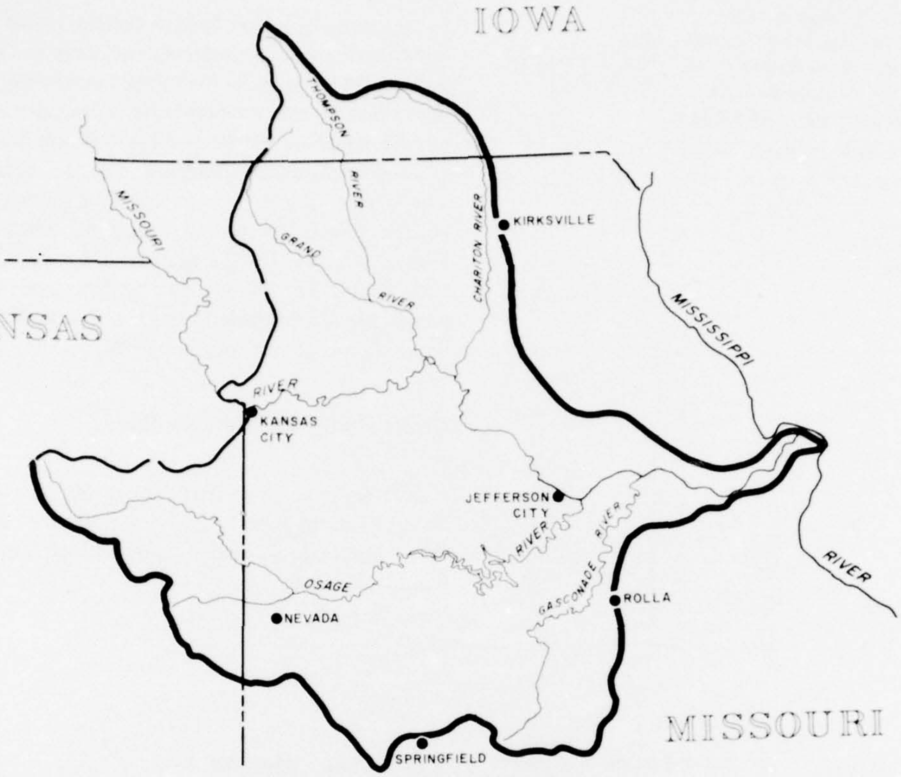


LOWER MISSOURI SUBBASIN

The Lower Missouri Subbasin includes the 6-county Kansas City Standard Metropolitan Statistical Area and the Missouri River drainage from Kansas City to the mouth. Total area is about 39,700 square miles; 2,500 in Iowa, 4,500 in Kansas, and 32,700 in Missouri. While principally agricultural, with 70 percent of the area in cropland and pasture, it accounts for more than one-fourth of the total Missouri Basin population (1960). The Kansas City SMSA, with a 1960 population of 1,092,500, accounts for about 50 percent of the subbasin population and is the largest metropolitan area in the Missouri River Basin.

Water Resources

Average annual runoff ranges from about 6 inches in the western part of the subbasin to almost 14 inches in the extreme southeastern part, averaging about 10 inches throughout; however, the area is subject to recurring wet and dry cycles. In dry years, the annual flow may be as little as 15 percent of the long-term average, while in wet years, the volume may be 2 to 3 times as great as the average.



Ground water is available in significant quantities in the Paleozoic rocks in the southeastern and eastern parts of the subbasin and in river alluvium along the Missouri River. Lesser quantities are found in glacial materials in the northern and northwestern portions and in the predominantly clay and silt-type Pennsylvanian rocks. The widespread availability of ground water at relatively shallow depths has been a big asset in serving small farms and domestic needs. Where sufficient quantities are available, large amounts of ground water are used for municipal and industrial supplies, and it serves most of the limited irrigation in the subbasin. Apparently, there has been little net effect in water levels as a result of this usage.

Urban pollution is the principal source of the existing quality of water problems. In 1965 the subbasin had 291 central water supply systems serving 1.8 million people or about 82 percent of the 1960 population. Of this number of communities, 203 had public sewerage systems with 15 providing only primary treatment and 178 having secondary treatment plants. Including a significant load from connected industrial plants, these plants reduced the total pollution load from about 2.8 million to 1.6 population equivalents. While most of the industrial wastes are so treated, some of them do not receive any treatment. Many of the smaller tributaries with low or erratic flows do not have the capability to handle the treated waste they receive. Additional treatment or augmentation of low flows will be needed to meet water quality standards.

Wastes from oil and gas fields are under strict surveillance though they are exceptionally high in chlorides and sulfates. Acid mine drainage is a problem in the Little Chariton and Osage river basins. Attempts to control this source of pollution are being undertaken at old mine sites and preventive measures are being initiated at new locations.

Fisheries in reaches of about 30 streams totaling about 460 miles are known to be degraded or partially degraded by pollution. Included are over 100 miles of the Missouri River, about 30 miles of the Big Blue River, and a reach of the Big Piney River.

The Kansas City metropolitan area was the subject of a Federal conference which resulted in the construction of primary waste treatment facilities for both the Kansas Citys. Construction of interceptors is proceeding more slowly due to difficulties of construction in heavily congested urban and industrial areas. Some communities along the Missouri River still are discharging untreated wastes into the river. Many waste treatment plants in this subbasin (and in many other parts of the Missouri River Basin) are over 15 years old. Rehabilitation and expansion is needed to keep abreast with the population and industrial expansion in the basin.

There are 17.3 million acre-feet of streamflow from the subbasin that is tributary to the Missouri River. Quality-of-water data are unavailable as a basis for a dissolved solids concentration estimate of all the outflow. Data for 9.2 million acre-feet of streamflow shows a dissolved solids concentration of about 235 mg/l. This indicates generally good quality water in the subbasin and accounts for a reduction in the Missouri River outflow dissolved solids concentration to about 390 mg/l. The dissolved solids in the subbasin streamflow are primarily from natural runoff although there is some influence from return flow from 5,000 acres of irrigation and relatively heavy municipal, mining, and industrial use.

Flood and Erosion Control

The existing flood and erosion control projects are summarized in table 89. Many of these improvements are single-purpose oriented. Others are multiple-purpose in character. The summary does not include the numerous private and locally constructed improvements throughout the subbasin, nor does it include upstream improvements, which provide substantial additional benefits at the Kansas Citys and along the Missouri River flood plain.

Of the 2,765,000 acres of land subject to flooding in the subbasin, 619,000 are in the Missouri and Kansas River flood plains (within the Kansas City SMSA) and are protected to some degree by upstream reservoirs. Of this latter area, 20,400 urban acres at the Kansas Citys receive a high degree of levee protection and account for about 52 percent of the total damage prevented by subbasin projects.

In the absence of existing projects, the annual flood losses would be about $101 million. The existing projects reduce these losses by about 68 percent, to $33,620,000. However, the total Kansas City urban area annual damages, in the absence of existing projects,

Flood Control By Reservoirs, Channel Improvements, And Levees Is Essential For Protection of the Kansas Citys

Table 89 – EXISTING FLOOD AND EROSION CONTROL PROJECTS – LOWER MISSOURI SUBBASIN

Type	No.	Levees & Channels	Total Storage	Area Protected	Annual Damages Prevented
		(Miles)	(1,000 AF)	(1,000 AC)	($1,000)
Major Reservoirs	7		8,764	342	9,598
Upstream Watershed Projects	12				530
Reservoirs	12		50		
Channel Improvement	79	24			
Grade Stabilization	211				
Levees and Channels	6	181		139	15,126
Bank Protection	1	375			

would be about $92,296,000. The existing projects, including upstream reservoirs, reduce these damages more than 91 percent to $7,846,000, much of which is on uncontrolled tributaries and in areas not protected by local projects. In the remainder of the subbasin, outside the Kansas City urban area, the damage reductions by existing projects amount to about 38 percent.

Streambank erosion is widespread but the intensity is relatively low. Stabilization of the Missouri River has virtually eliminated the bank erosion threat on the main stem. The most severe problems exist along the lower reaches of the Grand, Chariton, and Gasconade rivers. In this subbasin, about 1,600 bank-miles, or 1.8 percent of the existing channel banks, are receiving serious erosion. Average annual losses due to streambank erosion are estimated to be $469,000. While areas of potential streambank erosion can sometimes be identified, it is difficult to predict the exact location or to estimate the probability of occurrence. These inherent uncertainties have been major factors in delaying corrective action since landowners are not inclined to invest large sums as insurance against unknown hazards.

Missouri River Revetments Control Erosion And Create New Land

Gully erosion problems are most severe in the northern part of the subbasin. Soil and climatic conditions combine with current land usage to result in moderate to high rates of gully growth and advance. Current estimates place land voiding and depreciation due to gully erosion at about 10,800 acres annually, with average annual losses of nearly $4.7 million.

Water Supply

The annual gross withdrawals for municipal, industrial, and domestic water use approximate 814,700 acre-feet, of which about 607,500 acre-feet are power cooling water from the Missouri River. About 75 percent of the demand is met from surface sources, 19 percent from ground water, and 6 percent from a combination of the two. A total of 291 public water supply systems serve 1,800,000 people, about 90 percent of the subbasin population, and provide substantial amounts of water for industrial use. In addition, there are 96 separate industrial systems, including 24 power cooling systems. Except for power cooling water from the Missouri River, principally at and near Kansas City, no one industry dominates the area in water use. Other industrial and power cooling water requirements are held to a minimum by the use of recirculating systems.

At present, only about 5,000 acres of land are being irrigated, principally from wells in river alluvium along the major streams. The annual volume of water used for irrigation is about 3,000 acre-feet.

Livestock water supplies are adequate to meet requirements except in localized areas. During prolonged droughts, farm ponds in these areas may be entirely depleted and in some cases the ground-water levels decline until wells fail. Of the 10.3 million acres of land with permanent-type grazing vegetation, 75 percent has livestock water supplies of satisfactory quality and quantity and adequate distribution of facilities within suitable travel distances. About 51 percent of the livestock water is supplied from ground sources, and the remainder from surface water. There are about 66,000 livestock water ponds with 97,000 surface acres which

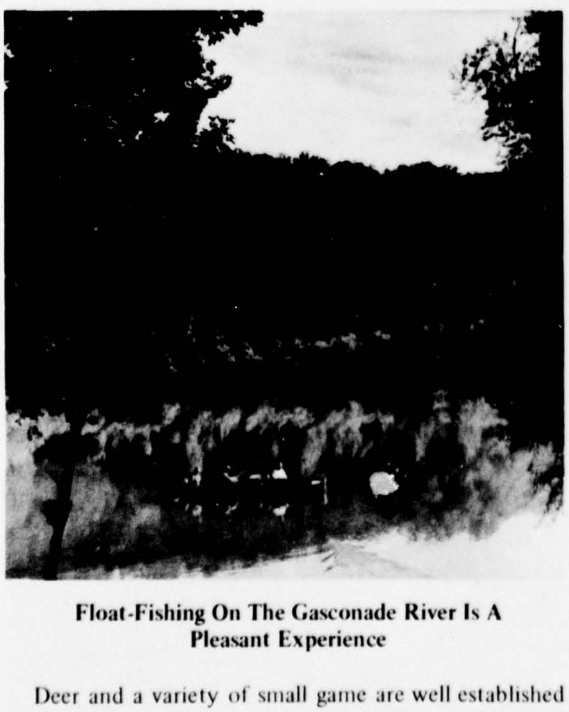
account for about 88 percent of the surface sources. The remainder is from 14,000 surface acres in streams, natural lakes or other impoundments, and incidental supplies in erosion and grade control structures.

Electric Power Generation

It is estimated that in 1965 the subbasin required about 10 billion kwh of electric power. To meet this requirement, 8.9 billion kwh were generated within the subbasin and the remainder supplied by imports. Steam-electric plants accounted for about 92 percent of the subbasin electrical generation, hydroelectric plants about 6 percent, and the remaining 2 percent was produced by numerous small internal combustion plants. The consumptive water use for thermal power production in 1965 was estimated at 10,000 acre-feet.

Fish, Wildlife, and Recreation

There are almost 8,000 miles of fishing streams in the subbasin, of which 307 miles are rated of national importance and 573 miles are of statewide importance. In addition, there are about 214,000 acres of large impoundments and 40,000 acres of farm ponds that provide sport fishing. The annual capacity for sport fishing is estimated as 7.9 million fisherman-days, while the estimated current usage is 5.7 million.



Float-Fishing On The Gasconade River Is A Pleasant Experience

Deer and a variety of small game are well established in the subbasin. Cottontail, mourning dove, and squirrel are presently underharvested, but the waterfowl resource is used at or near capacity. The total hunting capacity of game population is estimated as 4.1 million hunter-days which compares with the current usage of 2.6 million. Although the hunting and fishing capacities exceed present use, the total projected demands exceed the capabilities by significant margins. This seeming anomaly is due to a poor distribution of facilities in relation to population centers and restricted public access to fishing and hunting areas, especially on private lands.

State and local recreation areas provide a significant portion of the recreation opportunities and the bulk of the individual sites. The two sectors combined account for approximately 16 percent of the total recreation lands and waters (excluding the Missouri River) and 68 percent of the intensively developed area. Federal lands and waters also are very important. They furnish 71 percent of the total recreation area but only 3 percent of the developed land. The private sector also is recreationally quite important in this subbasin.

Approximately 85 percent of the current and rather intensive demand is created by subbasin residents and those living in metropolitan areas near the subbasin. In addition, a band of heavy demand is created between Kansas City and St. Louis by concentrated tourist traffic.

A current general shortage of facilities exists for games and sports, hiking and walking for pleasure, winter sports, and boating and water skiing. Due to regional supply/demand imbalances, variable shortages of swimming, picnicking, camping, nature walks and other facilities exist in a number of areas. Severe summer crowding in certain Missouri State Parks attests to this fact. Boating opportunities are also quite limited in some areas.

Land Conservation and Drainage

Currently, 10.2 million acres of the privately owned lands in the subbasin are used for crop production, 7.3 million acres are used for pasture and range, 5.8 million acres are in forest and woodlands, 793 thousand acres are in other agricultural uses, and 717 thousand acres are in nonagricultural uses. About 5,000 acres of cropland are irrigated annually. About 177 thousand acres of Federal land are used for agricultural purposes; seven thousand are grazed and 170 thousand produce forest products. An additional 108 thousand acres of Federal land are used for nonagricultural purposes.

Of the 10.2 million acres used for cropland, 9.2 million acres, or 90 percent, are suitable for sustained cultivation with proper management and conservation measures. The remaining one million acres of cropland are not suitable for continuous cultivation without sustaining damage to the soil resources. Conversely, about 2.3 million acres of pasture and range are physically suitable and can be used for sustained crop

production with proper management and conservation measures.

Wind and water erosion seriously affect lands in the subbasin. Through their own efforts and with Federal technical assistance and cost-sharing available to them, the owners and operators have installed adequate conservation treatment and management on 9.7 million acres of the private agricultural lands. Management-type practices on 5.5 million acres and mechanical or vegetative-type practices on 9.6 million acres are needed to provide adequate levels of conservation treatment and management.

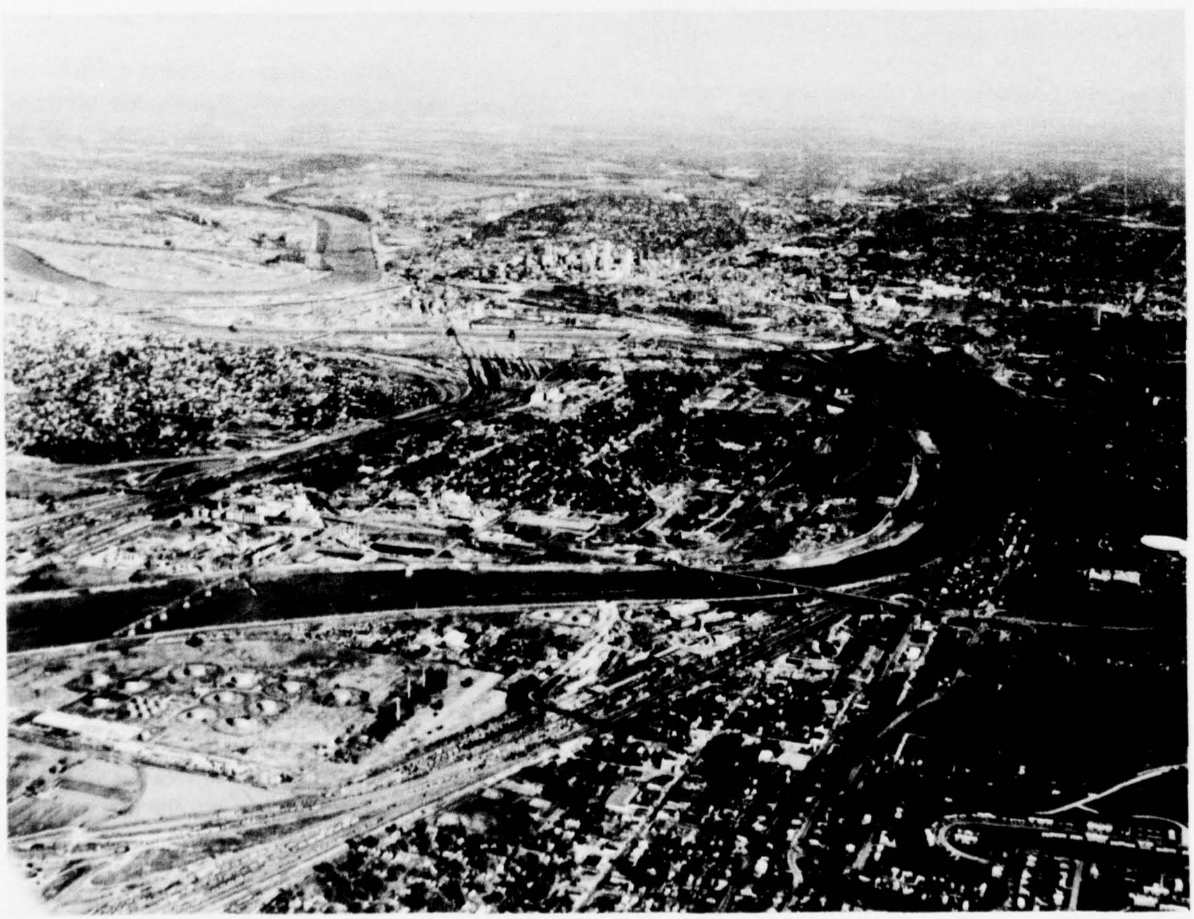
On federally owned lands, 83 percent, or 237 thousand acres are currently adequately treated and managed. The remaining 48 thousand acres in the subbasin need improved conservation treatment and management for sustained use without deterioration.

There are approximately 3.3 million acres of agricultural land in the subbasin subject to excess water problems. Currently, 1.4 million acres of cropland have been provided with adequate drainage. Of the remaining 1.9 million acres of land subject to excess water, 1.7 million acres are considered potentially suitable and feasible to drain. About 38 percent of this area is currently cultivated and current use would be improved by allowing timely operations. An additional 636 thousand acres of pasture and range and 464 thousand acres of forest and woodland are subject to problems of excess water and are suitable for conversion to cultivated uses. About 300,000 acres will require project-type measures to remove excess water.

About 120 thousand acres, or four percent of the land with excess water problems, are considered infeasible to drain. Of this total, 34 thousand acres are currently used for cropland and should be converted to non-crop uses. This and the remainder should be used for grazing and woodlands and managed to utilize its natural value as wildlife habitat.

Planning Objectives

This subbasin contains about 28 percent of the region's population and includes the two metropolitan centers of Kansas City and Springfield. The present



The Kansas Citys

economy is noted for the production, marketing, processing, and distribution of agricultural products, automotive and aircraft assembly, electronic equipment, space craft and rocket engines, and many other industrial activities. Most minerals produced are construction materials such as stone, crushed rock, sand, and gravel. In the Ozark region, lumber is harvested for commercial uses.

Within the context of the overall planning objectives, the principal goals of the subbasin are to support the urban-industrial requirements for water, land, and environmental quality, an increasing efficiency and intensification of agriculture, and the control of floods. Investigations of water and related land resources in the past have been extensive, some Federal projects have been constructed, and many other projects are authorized for construction. Extensive programs at the State level have also been implemented, especially the provision of access to areas for recreation and fish and wildlife purposes. Accordingly, during plan formulation much was known of the water resource potentials of the area, and alternative considerations dealt principally with a proper orientation of future demands to previously studied projects and to those few cases where alternatives were available either for development of water resources in the traditional sense or preservation of streams for enjoyment of their natural beauty.

The framework plan, therefore, was formulated to meet indicated future demands and encompasses many proposals studied in the past. During future detailed evaluations, site alternatives will have to be explored further to determine the most efficient methods for storage and streamflow regulation. Preliminary screening studies for the framework plan were made, but more in-depth economic studies will be required.

Specified Non-Federal Programs and Modifications of Existing Developments

It is anticipated that the current irrigation on 5,000 acres of land will be accelerated considerably over the projection period. Studies made at the University of Missouri indicate an increasing need for maintaining proper soil-moisture balances and thereby attaining economic efficiencies. The projected rate of this development using ground-water supplies will be limited mostly to the major river flood plains and will be carried out by the private sector. State, local, and private recreational development has been projected at rates reflecting fulfillment of indicated need, while land conservation programs will be continued at a reduced rate from the historic past. This is attributed to a lesser amount of land still requiring treatment.

Action is now underway to modify the existing Thomas Hill Reservoir on the Little Chariton River to provide an additional 16,000 acre-feet of storage for flood control purposes. To meet expanding recreational requirements, access to existing resources should also be provided. As is the case with the Middle Missouri Subbasin, much of this could be to the Missouri River. These features of the subbasin framework plan are summarized in table 90.

Table 90 – SPECIFIED NON-FEDERAL PROGRAMS AND MODIFICATIONS OF EXISTING DEVELOPMENTS, FRAMEWORK PLAN – LOWER MISSOURI SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SPECIFIED NON-FEDERAL PROGRAMS				
Private Ground-water Irrigation	1,000 AC	108	266	412
State, Local, and Private Recreation	1,000 AC	61	199	292
Private Land Conservation	1,000 AC	1,445	3,694	5,650
MODIFICATIONS OF EXISTING DEVELOPMENTS				
Reservoirs	1,000 AF	16	16	16
Fishing & Recreation Access	Number	211	241	271

Water Control and Related Land Development

Extensive surface water control developments are included in the subbasin framework plan as a means for meeting future needs as well as the objectives for this area. Table 91 summarizes the physical features of this component of the subbasin framework plan.

The surface water control features include 1,005 multiple-purpose reservoirs providing a total storage of 12,604,000 acre-feet. Twenty-six reservoirs having individual storage capacities greater than 25,000 acre-feet would provide 9,640,000 acre-feet of this total, while 979 reservoirs with less than 25,000 acre-feet of individual storage would provide 2,964,000 acre-feet of storage. In addition to the multiple-purpose storage reservoirs, 658,000 acre-feet of single-purpose storage would be provided – 539,000 acre-feet for general recreation and 119,000 acre-feet for fish and wildlife purposes.

Table 91 – WATER CONTROL AND RELATED LAND DEVELOPMENT
FRAMEWORK PLAN – LOWER MISSOURI SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
SURFACE WATER CONTROL				
Storage	1,000 AF	6,528	12,092	13,262
Local Protection	Miles	873	1,193	1,193
Bank Stabilization	Miles	14	43	57
Grade Stabilization	Structures	877	1,336	1,559
LAND DEVELOPMENT				
Recreation, Fish and Wildlife	1,000 AC	198	321	331
Group Drainage	1,000 AC	40	70	100
Surface Water Irrigation				
Non-Federal	1,000 AC	122	323	558
Public Land Conservation	1,000 AC	6	24	33

Of 12,604,000 acre-feet in multiple-purpose impoundments, 1,519,000 acre-feet would be in inactive storage, 4,343,000 acre-feet would be for joint beneficial uses, and 6,742,000 acre-feet would be for exclusive flood control. The joint use storage would be used as follows:

Streamflow Augmentation, Quality	381,000 acre-feet
Irrigation	252,000 "
Municipal & Industrial	542,000 "
Hydro-electric power	213,000 "
Recreation, Fish & Wildlife	2,172,000 "
Flood Control	Incidental benefits from regulation

Channel and levee improvements covering 42 miles would be provided for local flood protection at Kansas City (Blue and Little Blue rivers), Excelsior Springs, Pleasant Hill, Smithville, and Jefferson City in Missouri, and at Osawatomie, Kans., and 401 miles would be associated with watershed improvements. The remaining 750 miles are designated for agricultural levees along the Missouri River. Other in-stream controls would consist of 57 miles of bank stabilization measures primarily located on the Osage and Grand rivers, and 1,559 grade control structures to prevent gully erosion.

Related land developments would include 331,000 acres of land for recreation and fish and wildlife purposes; group systems for the drainage of 100,000 acres; and the irrigation of 558,000 acres of land by diversions of surface waters regulated by the reservoir systems.

Environmental Enhancement and Non-Structural Measures

The additional environmental features and the magnitude of a flood plain management program for the subbasin reflect the same features outlined previously for the other subbasins. These are summarized in table 92.

Table 92 – ENVIRONMENTAL ENHANCEMENT AND NON-STRUCTURAL MEASURES
FRAMEWORK PLAN – LOWER MISSOURI SUBBASIN

Feature	Unit	Amounts		
		1980	2000	2020
		(Cumulative Above Current)		
ENVIRONMENTAL				
Sewage Treatment Plants[1]	Number	388	543	1,400
Water Supply & Treatment	1,000 AF/YR	149	367	819
Fish and Wildlife				
Wetlands	1,000 AC	0	10	10
Management Areas	1,000 AC	87	91	91
Fish Hatcheries	Number	0	0	2
Fish Impoundments	Number	21	26	31
Scenic Rivers	Miles	35	358	358
Trails	Miles	0	350	350
NON-STRUCTURAL				
Flood Plain Management				
Area	1,000 AC	591	1,570	1,729
Flood Hazard Reports	Number	17	74	90

[1] Includes existing plants.

Land and Water Changes

Net land use changes that would result from the subbasin framework are shown in table 93.

Water supply studies indicate a streamflow depletion of about 1.6 million acre-feet. Ground-water withdrawals from the valley alluvials, on the other hand, may temporarily deplete water tables, but full restoration from streamflow infiltration may be expected within 1 to 2 years. Since "mining" of ground water in the subbasin is improbable, no depletions were assigned to ground-water use and the effect would be to directly diminish local streamflows. Table 94 presents the withdrawals and streamflow depletions that would result from the subbasin framework plan.

Table 93 – LAND USE CHANGES, FRAMEWORK PLAN – LOWER MISSOURI SUBBASIN

Principal Use	Net Land Use Changes			
	1965-1980	1980-2000	2000-2020	1965-2020
	(Thousand Acres)			
Irrigated Cropland	+230	+359	+381	+ 970
Non-irrigated Cropland	- 614	- 801	- 724	- 2,139
Forest and Woodland	- 231	- 222	- 222	- 675
Pasture and Range	- 296	- 291	- 401	- 988
Trans., Urban, & Built-up	+238	+491	+812	+1,541
Other (Rec, F&WL, & Other Uses)	+455	+306	+ 85	+ 846
Water	+218	+158	+ 69	+ 445

Table 94 – WATER WITHDRAWALS, DEPLETIONS, AND OTHER CHANGES, FRAMEWORK PLAN – LOWER MISSOURI SUBBASIN

	Withdrawals						Depletions					
	Ground			Surface			Ground			Surface		
	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
	(Cumulative Above Current – Thousand Acre-feet/Year)											
Irrigation	65	164	263	74	194	328				139	358	591
M&I, Rural Domestic	38	91	205	111	276	614				28	77	186
Thermal Power				172	277	350				15	66	109
Livestock	17	35	61	17	38	68				34	73	129
Land Conservation				17	19	20				17	19	20
Wetlands, Fish and Wildlife				14	17	19				14	17	19
Evaporation				214	437	533				214	437	533
Total	120	290	529	619	1,258	1,932				461	1,047	1,587

Costs

Estimates of first costs for all features of the subbasin framework plan indicate a total investment requirement approximating $3.7 billion. Average annual OM&R costs would range from $28.5 million by 1980 to $102.8 million by 2020. Figure 47 presents cost estimates for the subbasin framework plan at the 1980, 2000, and 2020 target years.

The first costs distributed to each functional item included in the subbasin framework plan are shown graphically in figure 48. As can be noted from figure 48, the largest share of the total investment would be for recreation, $1 billion, or 27 percent; followed by flood control, $799 million, or 22 percent; land conservation, $507 million, or 14 percent; and water supply and treatment, $457 million, or 12 percent.

Further insight to investment requirements is provided by an additional disaggregation of costs to reflect not only functional uses, but also the Federal – non-Federal cost sharing relationships. Based on existing legal and policy considerations, initial Federal investments of $1,228 million would be required, exclusive of $85.9 million for initial cost-sharing. Of the initial amount, $139.5 million would have to be repaid over the long-term future by non-Federal institutions, resulting in a net Federal investment of $1,088.5 million. Similarly, non-Federal programs having a first cost of $2,359.7 million would be netted to $1,474.9 million by grant and assistance programs ($884.8 million) of the Federal Government. On the basis of initial investments, the Federal – non-Federal cost-sharing for the total framework plan would approximate 58 and 42 percent, respectively. On the basis of net costs, however, the cost-sharing could approximate 54 percent Federal and 46 percent non-Federal. The distributed costs together with cost-sharing requirements are shown on table 95.

Table 95 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY – LOWER MISSOURI SUBBASIN

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						41.2		41.2
State & Local Recreation						840.7	336.4	504.3
National Recreation Area								
Private Land Conservation						507.0	253.5	253.5
Irrigation Rehabilitation								
Access						3.8		3.8
Refuges								
Hatcheries								
Reservoirs	5.7	5.7						
Water Control and Related Land								
Single Purpose F. C.	319.5	255.6			63.9			
Other Single Purpose Res.								
Grade Stabilization	61.7	49.3			12.4			
Bank Stabilization	1.4	1.0			.4			
M. P. Reservoirs	896.0	(520.9)	(375.1)	(139.5)				
Water Quality			41.8					
Irrigation			28.8	28.8				
M & I			57.4	57.4				
Power		7.0	26.3	33.3				
Recreation		40.0	110.4	20.0				
Fish and Wildlife			110.4					
Flood Control		473.9						
Surface Water Irrigation						57.5		57.5
Group Drainage	5.0	2.6			2.4			
Public Land Conservation	.4	.4						
Environ. and Non-Structural								
Sewage Treatment						277.0	83.1	193.9
Water Supply & Treatment						399.1	199.6	199.5
Fish and Wildlife								
Wetlands	2.5	2.4			.1			
Management Areas						24.1	12.2	11.9
Fish Hatcheries	5.0	2.5			2.5			
Fish Impoundments	8.6	4.4			4.2			
Scenic Rivers	5.9	5.9						
Trails	.8	.8						
Flood Plain Management	1.4	1.4				209.3		209.3
Forest Management								
Precip. Management								
Totals	1,313.9	852.9	375.1	139.5	85.9	2,359.7	884.8	1,474.9

1965-2020 Total: 3,673.6

Table 96 – FRAMEWORK PLAN FOR 1980 – LOWER MISSOURI SUBBASIN

Plan Feature	Description and Purpose	Initial First Costs			Annual Operation, Maintenance and Replacement Costs		
		Federal	Non-Fed	Total	Federal	Non-Fed	Total
		($ Million)			($ Thousand)		
Storage Reservoirs							
Modifications	Raise embankment of Thomas Hill Reservoir on the Little Chariton River to provide 16,000 acre-feet of additional storage for flood control.	5.7	0	5.7	56	0	56
Single-Purpose Impoundments	Recreation and fish and wildlife reservoirs having 176,000 acre-feet of storage.	Costs are included below with recreation and fish and wildlife.					
Multiple-Purpose Impoundments, Major and Minor	14 impoundments having 5,136,000 acre-feet of storage and 410 minor reservoirs with a capacity of 1,216,000 acre-feet for water quality, irrigation, M&I, power, recreation, fish and wildlife, and flood control.	522.0	0	522.0	1,657	596	2,253
Irrigation							
New Systems	Provide 230,000 acres of irrigation subbasin-wide.	0	23.4	23.4	0	2,123	2,123
Group Drainage	Provide 40,000 acres of public or group drainage.	1.0	1.0	2.0	0	80	80
Local Flood Protection	Channel and levee improvements involving 873 miles for protection of Kansas City (Blue and Little Blue Rivers), Excelsior Springs, Pleasant Hill, and Smithville, Mo., and Osawatomie, Kans., agricultural lands, and both urban and agricultural areas associated with watershed improvements.	175.6	43.9	219.5	0	578	578
Grade Stabilization	877 grade stabilization structures for erosion control.	29.7	7.4	37.1	0	66	66
Bank Stabilization	Bank protection on the Osage and Grand rivers covering 14 miles.	0.3	0.1	0.4	0	4	4
Recreation	The development of 61,000 acres by the State, local, and private sector; providing 211 new access sites to existing water and 35 miles of scenic rivers (Niangua River).	46.9	72.4	119.3	0	5,359	5,359
Fish and Wildlife	87,000 acres for game management and 21 new fish impoundments.	9.9	9.7	19.6	0	184	184
Water Supply and Treatment	Treatment facilities to serve 674,000 people and development of individual supplies.	57.5	57.5	115.0	0	4,150	4,150
Sewage Treatment	Enlargement of 178 secondary facilities, additions to 15 secondary facilities, and construction of 195 new secondary facilities.	21.9	51.1	73.0	0	7,600	7,600
Land Conservation	Land treatment measures for 1,445,000 acres of private land and 6,000 acres of federally owned land.	67.1	67.0	134.1	1	5,500	5,501
Flood Plain Management	Preparation of 17 flood hazard reports covering 591,000 acres of flood plains.	0.3	95.5	95.8	40	477	517
Total		937.9	429.0	1,366.9	1,754	26,717	28,471

FIGURE 49

LOWER MISSOURI SUBBASIN

PRINCIPAL WATER CONTROL FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

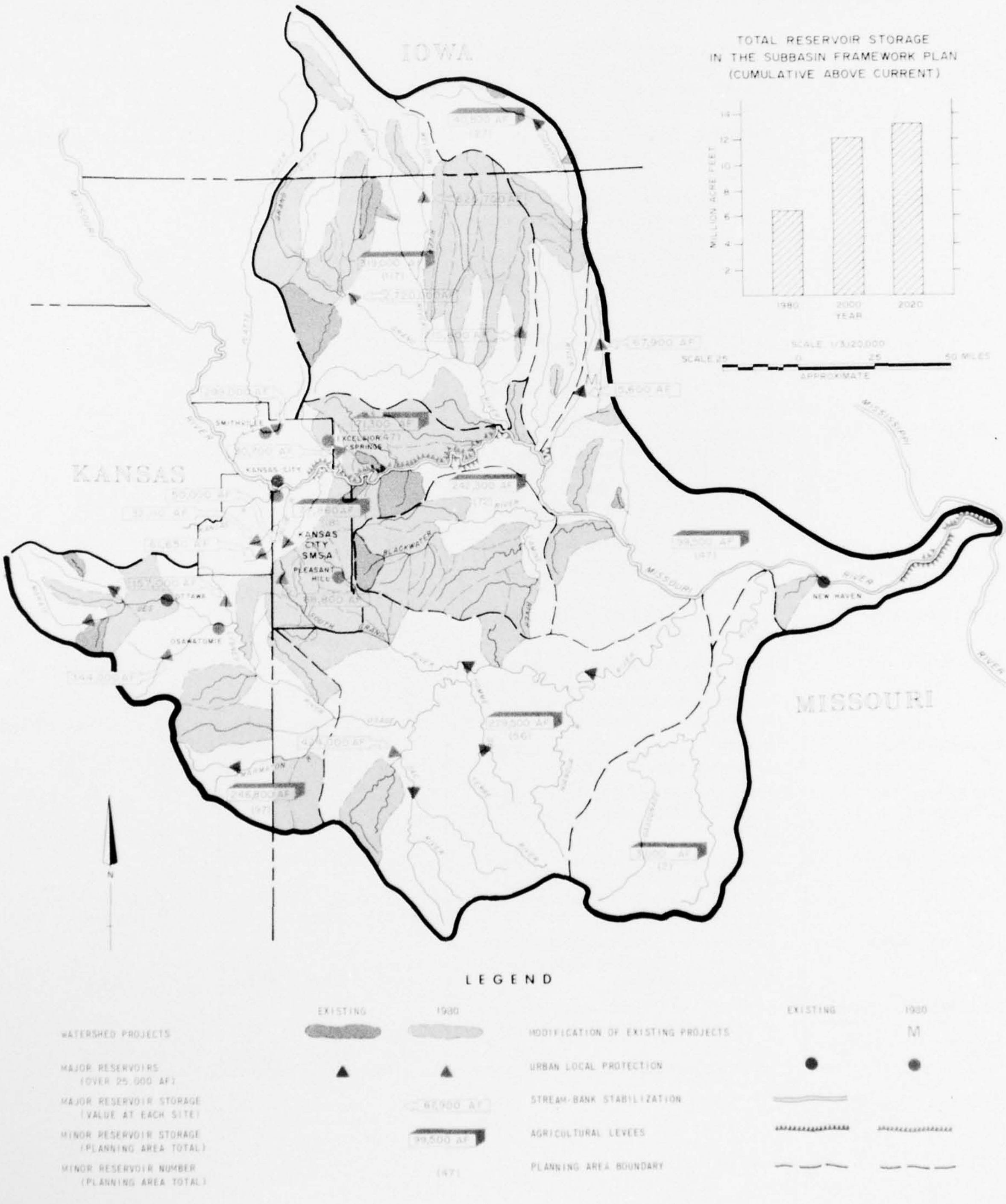


FIGURE 50

LOWER MISSOURI SUBBASIN

RELATED LAND DEVELOPMENT FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

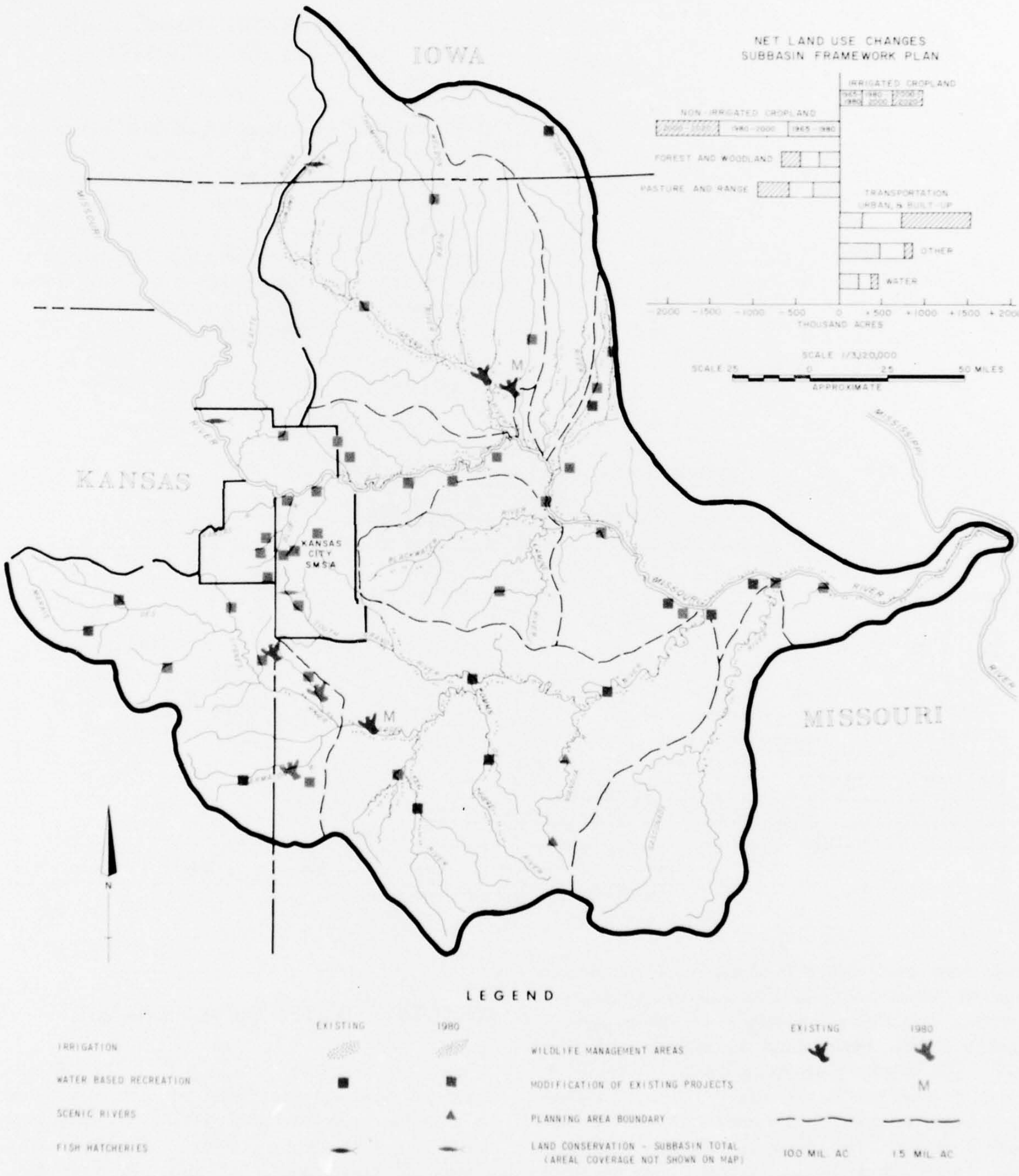
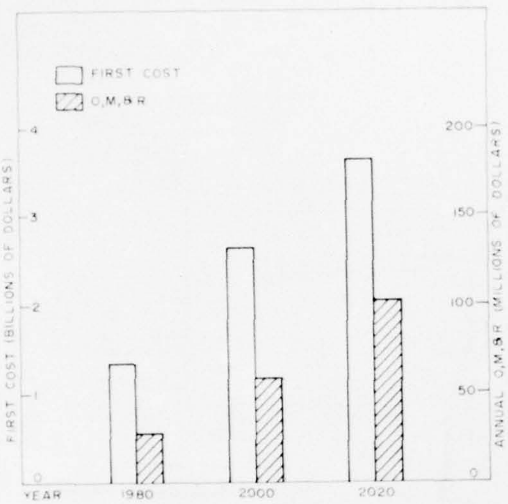


FIGURE 47
ESTIMATED FIRST COSTS AND
ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENTS
FRAMEWORK PLAN
LOWER MISSOURI SUBBASIN
(cumulative above current)



Short-Range Framework Plan

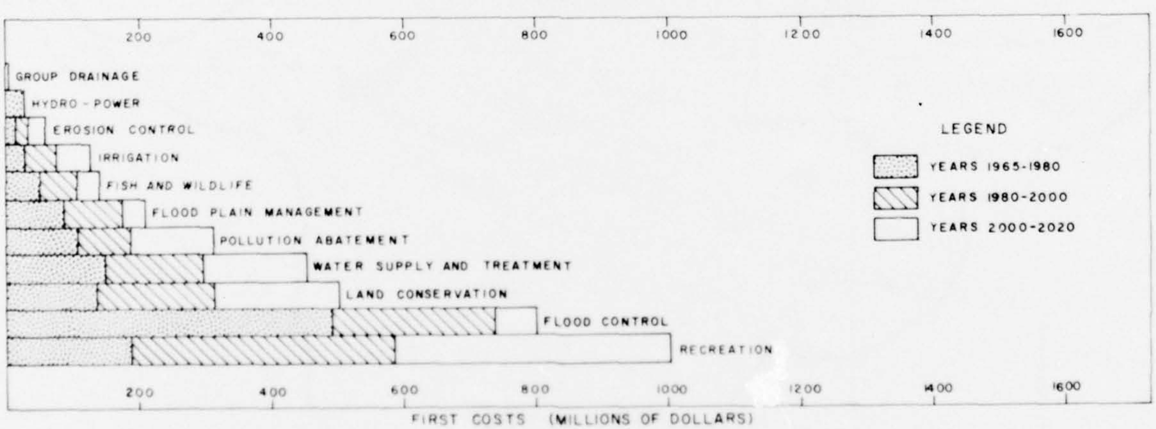
The short-range (1980) features of the subbasin framework plan are summarized in table 96. Figures 49 and 50 show the major features of the 1980 framework plan by geographical location.

IMPACTS OF SUBBASIN FRAMEWORK PLANS ON WATER AND RELATED LANDS

During plan formulation, future land use changes were based on a recognition of the requirements for transportation, urban, and built-up areas as well as the conversions of land use for the various purposes included in the subbasin framework plans. Table 97 presents a basin summary of the net land use changes anticipated over the study projection period and is a summation of subbasin values presented in the preceding section.

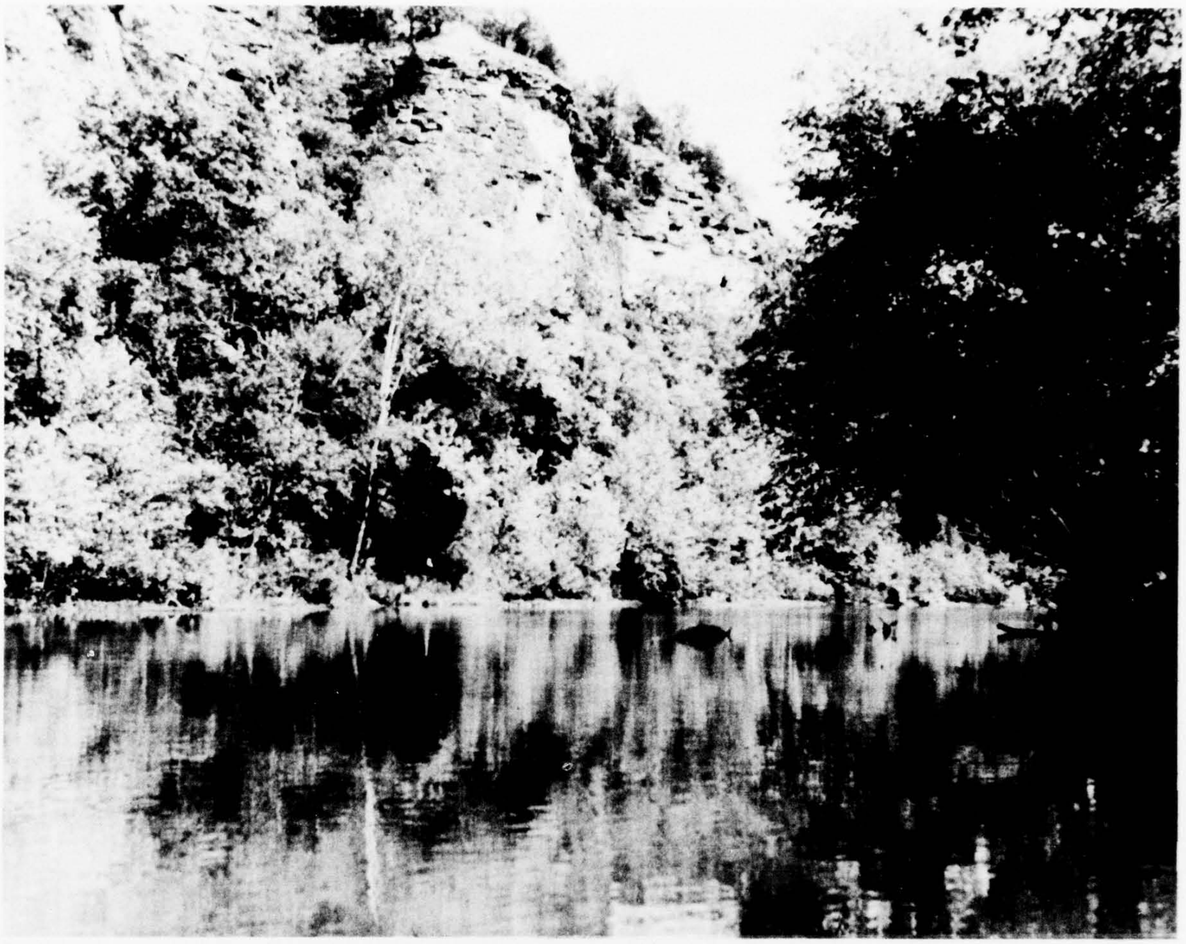
As can be noted from table 97, a total of 22 million acres of agricultural land in the categories of non-irrigated cropland, forest and woodland, and pasture and range would be converted to other uses. Of this amount, over 10 million acres would be converted to irrigated cropland, with the net depletion of the current agricultural land base being about 12 million acres. The conversions to other purposes are shown in table 97. It should be noted that for the category "Other," 5 million acres would be primarily for recreation and fish and wildlife purposes. The additional water area of about 2 million acres reflects multiple-purpose storage reservoirs and other impoundments included in the subbasin framework plans.

FIGURE 48
DISTRIBUTION OF COSTS BY FUNCTIONAL PURPOSES
FRAMEWORK PLAN
LOWER MISSOURI SUBBASIN



IMPACTS OF WATER SUPPLY CHANGE

Water supply changes resulting from the subbasin framework plans were analyzed to insure the availability of water for the intended uses as well as the effects on the Missouri River. The withdrawals and depletions of ground and surface waters for various uses were summarized for each subbasin in the preceding section. Table 98 sums the individual items into basin totals.



The Gasconade River Has Scenic Qualities

Water Availability and Use

The water-depleting effects of the subbasin frameworks do not indicate the degree to which the total water supply in each subbasin is used and reused, or the magnitude of the residual supply. As can be noted from table 98, the depletions are net values recognizing increased water yields to each subbasin's normal water supply by imports, precipitation management, forest management, and miscellaneous conversions of water use. Figure 51 indicates the degree of use of the water supply originating in each subbasin, the dependence of subbasin framework plans on increased water yields, and the magnitude of the remaining water supply.

As is indicated in figure 51, the subbasin framework plans deplete less than one-half the available water supply in the Upper Missouri, Yellowstone, Eastern Dakota, Middle Missouri, Kansas, and Lower Missouri subbasins through the year 2020. In none of these subbasins is increased water yields from various management programs a significant portion of the total water

Table 97 – LAND USE CHANGES, FRAMEWORK PLAN – MISSOURI RIVER BASIN

Principal Use	Net Land Use Changes			
	1965-1980	1980-2000	2000-2020	1965-2020
	(Thousand Acres)			
Irrigated Cropland	+2,647	+3,347	+4,457	+10,451
Non-irrigated Cropland	-3,374	-3,952	-5,381	-12,707
Forest and Woodland	- 480	- 634	- 714	- 1,828
Pasture and Range	-2,128	-2,515	-2,972	- 7,615
Transportation, Urban, & Built-up	+ 832	+1,559	+2,467	+ 4,858
Other (Rec, F&WL, & Other Uses)	+1,812	+1,661	+1,660	+ 5,133
Water	+ 691	+ 534	+ 483	+ 1,708

FIGURE 51
AVERAGE ANNUAL STREAMFLOW DEPLETIONS AND AVAILABLE WATER SUPPLY BY SUBBASINS AND DEVELOPMENT PERIODS

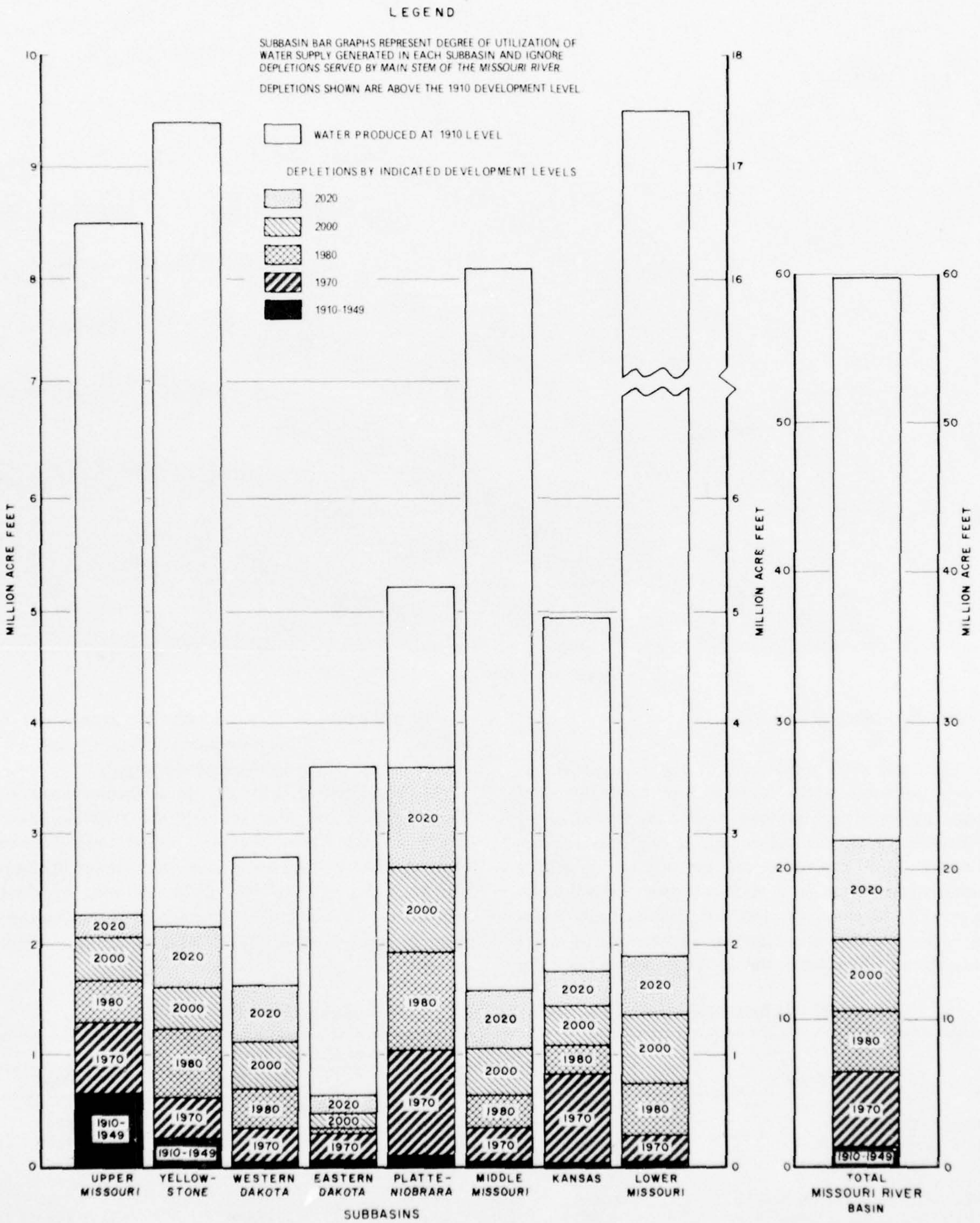


Table 98 – WATER WITHDRAWALS, DEPLETIONS, AND OTHER CHANGES, FRAMEWORK PLAN – MISSOURI BASIN

Service	Withdrawals						Depletions					
	Ground			Surface			Ground			Surface		
	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
	(Cumulative Above Current – Thousand Acre-feet/Year)											
Irrigation	1,896	3,981	6,996	3,684	7,730	12,675	1,267	2,292	4,044	2,339	5,547	9,327
M&I, Rural Domestic	166	337	616	921	1,709	3,087	12	29	55	564	971	1,642
Thermal Power	2	8	13	1,396	2,570	3,141	1	3	5	85	315	556
Livestock	92	198	376	128	266	418	46	95	157	174	369	635
Land Conservation				155	423	712				155	423	712
Wetlands, Fish and Wildlife				144	237	381				144	237	381
Evaporation				816	1,721	2,422				816	1,721	2,422
Imports (interbasin only)				-105	-337	-337				-105	-337	-337
Exports (interbasin only)				411	1,132	2,045				411	1,132	2,045
Forest Management				-117	-399	-436				-117	-399	-436
Precipitation Management				-203	-564	-1,270				-203	-564	-1,270
TOTAL	2,156	4,524	8,001	7,230	14,488	22,838	1,326	2,419	4,261	4,263	9,415	15,677

supply, or that needed to meet water demands therein. However, in the Platte River area of the Platte-Niobrara Subbasin, virtually all of the existing surface water supply would be used by 2020 and added water becomes an indispensable element of the framework plan. The critical areas of dependence on this added water are the South and North Platte river drainages. Preliminary analyses for these two systems indicate that the estimated depletions in the period 1910-2020 exceed the 1910 natural water supply. The level of development projected through 2020 can, therefore, be achieved only through provision of additional water, treatment, and reuse. Although the subbasin frameworks indicate that the additional supply would come from full development established water imports and the forestry and precipitation management programs, other alternatives should be considered in the future. These include the possibility of increasing imports, recycling waste waters, and restricting water uses. In the Western Dakota Subbasin, planned future water uses would result in depletions of over one-half the water supply, an unusually high ratio for a multi-stream subbasin. Future detailed studies should recognize this demand-supply relationship and the systems designed accordingly.

For the Missouri Basin, streamflow depletions would increase from a 1970 depletion of 11.7 million acre-feet to a total of 27.4 million acre-feet by 2020, a net increase of 15.7 million acre-feet. This magnitude of water use would significantly affect some services provided by the Missouri River main stem reservoirs and would reduce average annual flow levels near the mouth of the Missouri River from the current 53.6 million acre-feet to 37.9 million acre-feet.

Effects on the Missouri River

To evaluate the effects on the Missouri River and the residual flows to the Mississippi River, reservoir operation studies for the various future development levels, 1980, 2000, and 2020, were made. The results of these studies when compared with the current level of development indicate the effects of future basin development upon the basic main stem reservoir functions and on downstream flow conditions.

Long-range reservoir operation studies which cover the historic period from 1898 through 1968, but with potential developments at 1980, 2000, and 2020 levels, are exceedingly complex and involve the development of detailed criteria. As a consequence, even with maximum use of electronic computers, limitations on time and effort which could be expended prohibit an exhaustive investigation of alternate reservoir regulation criteria as a means for optimizing outputs from the system. With the many assumptions required to project the effects of basin development on future flows, such an investigation would serve no useful purpose at this time. However, the study that has been made, although exploratory in nature, does provide both qualitative as well as reasonably valid quantitative estimates of the effects that future basin development could have on the Missouri main stem reservoir system functions and on downstream river flows. The assumptions and criteria used and pertinent graphical material developed from the operation studies are presented in the appendix "Hydrologic Analyses and Projections" and are not repeated here.

The studies demonstrate that at all levels of development, current and future, the reservoir system would be fully effective for flood control with all runoff conditions experienced during the 1898-1968 period of record. Flows at Sioux City would always be at or below the level permitted by the downstream flood potential. Under current conditions of development, there would be 30 months during the record period when, due to the downstream flood potential, reservoir system releases would be reduced below levels required for flood storage evacuation purposes. At the 1980 development level,

reductions in releases would be required for only 6 months, while at the 2000 and 2020 levels, no such reductions would be required.

Sufficient releases or pumpage would be maintained from the reservoirs at all developmental levels to meet irrigation requirements. The effects of irrigation, as well as other consumptive uses, upon inflows into the system and releases from the system to satisfy demands were considered throughout the reservoir regulation study.

At the current level of basin development, navigation flows averaging 25-41 thousand cfs at key downstream points could be maintained for full 8-month navigation seasons for 66 years of the 71-year period of record. With the 1980 developmental level, the full length navigation seasons would reduce to 61 years; at the 2000 level, to 43 years; and by 2020, to only 15 years. Two drought periods during the record period have significant effects on the navigation service. For the 1930 drought period and at the 1980 level of development, substantial decreases in the navigation season lengths for 9 years would result; at the 2000 level, extreme reductions of 14 successive years would result and complete elimination for one year. The drought of the late 1950's and early 1960's requires navigation releases for the 2000 level of development to be reduced from full service for 10 successive years. By the year 2020, the effects of basin development on the navigation function becomes extreme. In only 15 years during the record period would it be possible to provide full 8-month navigation seasons, with a complete elimination of the service for 11 successive years during the 1930 drought and 2 successive years during the drought of the late 1950's. Shortened seasons would be quite common throughout the period of record. Table 99 shows the distribution of navigation season length for the 71-year period of record.

Table 99 – EFFECTS ON NAVIGATION SEASON LENGTHS BY FUTURE BASIN DEVELOPMENT

Season Length (Months)	Years Experienced for Development Levels			
	Current	1980	2000	2020
8	66	61	43	15
7	3	1	6	10
6	2	2	9	20
5		7	4	4
4			8	9
0			1	13
TOTAL	71	71	71	71

Water quality control requirements were based on the assumption that secondary sewage treatment of municipal and industrial wastes to a 95 percent BOD removal efficiency would be available by the year 2020 and that storage releases for temperature control would not be made. On this basis, all requirements on the Missouri River would be met throughout the period of record considering the future developmental levels.

The effects of future developments on hydroelectric capability of the reservoir system were also analyzed. The study indicates that the peaking capability would be reduced from a capacity of about 1,990 megawatts to approximately 1,920 megawatts by 2020. Annual system generation, on the other hand, would be reduced by about 37 percent during this same period, from 9.2 billion kwh currently to 5.8 billion kwh in 2020.

Figure 52 presents streamflow duration curves at certain key locations on the Missouri River and illustrates various flow conditions that may be anticipated over the study projection period. Considerable additional data from the operation studies may be found in the appendix "Hydrologic Analyses and Projections."

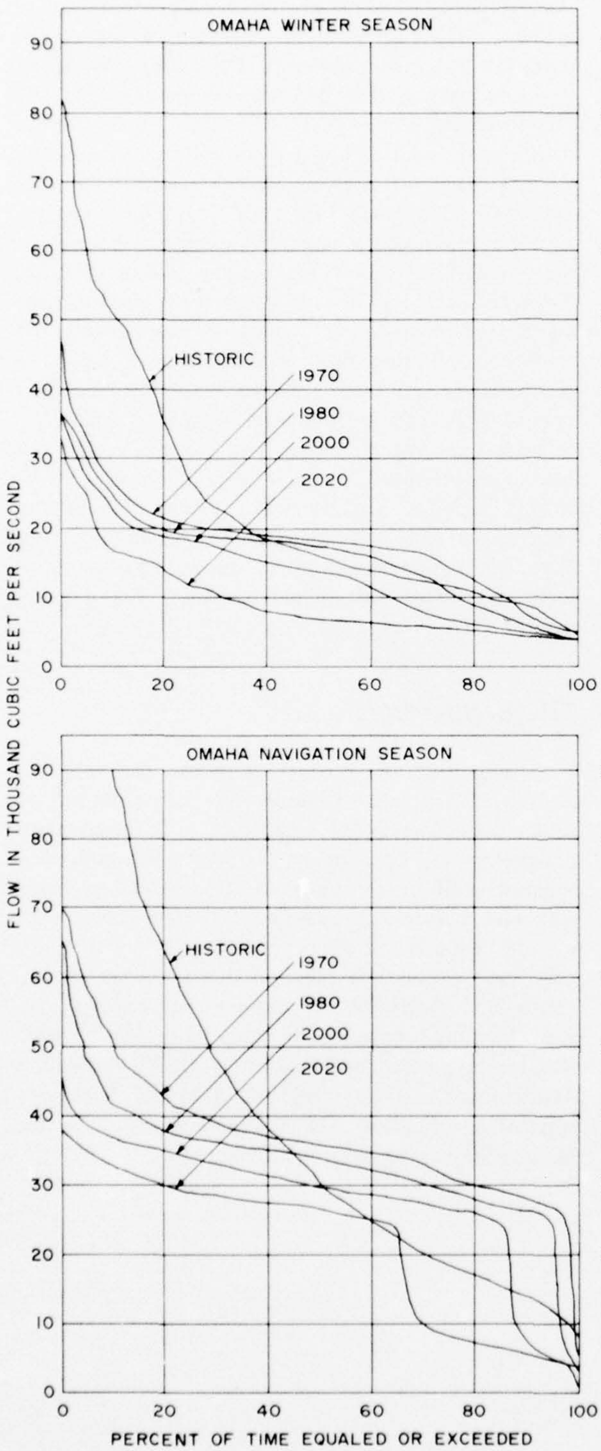
FUTURE DEVELOPMENTS ON THE MISSOURI RIVER

Plan formulation studies for the Upper Missouri, Western and Eastern Dakotas, Middle Missouri, and Lower Missouri subbasins included a consideration of improvements related to the Missouri River. For the most part, such considerations related to existing problems or opportunities that would not be significantly affected by possible water supply changes resulting from subbasin framework plan streamflow depletions. Accordingly, plan features such as storage impoundments on the Missouri River above Ft. Peck Reservoir in Montana, bank stabilization along the Missouri River, agricultural levees, establishment of a national recreation area at the main stem reservoirs, recreation access, and developments for recreation and fish and wildlife were included in the tributary subbasin framework plans.

The principal impacts of subbasin streamflow depletions on the Missouri River are to flow requirements in support of the existing navigation project and hydroelectric power generation. Moreover, residual flows at the mouth of the Missouri River must be recognized in any studies dealing with the lower Mississippi River.

Although potential Missouri River streamflow would be affected significantly by 2020, the reduction in hydropower peaking capability would only be on the order of 4 percent. However, system energy would be reduced significantly, an overall reduction of 37 percent over the projection period. This would suggest that in time the system should probably be converted to a peaking status and managed for this purpose. The reservoir operation studies, described in the preceding section, also assumed that the design tailwater elevations at Garrison, Fort Randall, and Gavins Point dams would require a lowering of the Missouri River channel bed by 7, 10, and 10 feet, respectively. For those reservoirs of

FIGURE 52
STREAMFLOW DURATION CURVES



the system cited, natural degradation to projected elevations has not materialized. Accordingly, it would appear desirable that the bed of the Missouri River be artificially lowered by dredging in order for the power values previously outlined to be realized. The cost of such channel work would approximate $30 million. In view of the results indicated by the reservoir operation analyses, studies should be initiated to determine the feasibility and practicability of converting the existing power plants to a peaking capability system, including the need for additional peaking power units, practicability of pump-back operations at the main stem dams, and the channel bed lowering. These studies should be aimed at a possible change-over to a peaking status and possible implementation of other physical improvements cited within the 1980-2000 time frame.

The reservoir operation studies also indicate that open-water navigation on the existing Missouri River waterway probably would not be viable after the year 2000 because of the lack of water to maintain necessary channel depths over a reasonable length of time. Certain alternative courses of action should then be considered. Inland waterway navigation could be eliminated and other modes of transport used. On the other hand, the river could be canalized through a series of locks and dams to support full season navigation. Another alternative would be to decrease channel depths, or the navigation season could be shortened and dredging used as a means for maintaining a 9-foot draft. It is premature to select a course of action that would not be required until 30 to 50 years in the future. However, on the assumption that inland navigation will be needed, the basin framework plan includes an item for slack-water dam and lock facilities at an estimated cost of $3 billion. As the need for action becomes more definitive in the future, the various alternatives would have to be carefully analyzed and the proper course of action determined.

In addition to the water supply impacts on the existing Missouri River navigation channel below Sioux City, recent studies indicate the probable feasibility and need for extending the existing navigation project from Sioux City to Gavins Point Dam. Such extension, based on existing reservoir operations, would require additional releases of about 500 cfs from Gavins Point Dam and Reservoir. Within normal system operations, this would not be of major significance. However, such extension of the existing navigation project would be subject to the same impacts as described previously. Therefore, a decision relative to implementing plans to extend the navigable waterway to Gavins Point Dam should be based on the same alternatives previously described, and such decision probably is not required before 1980. Accordingly, until a firm decision can be made, within the context of a framework plan an investment cost of $60 million is included for the year 2000 time frame.

A possible need for providing navigable channels on the Kansas River below Turner, Kans., and on the lower 3 miles of the Grand River in Missouri was also indicated by the framework study. The former is included in the framework plan since plan formulation studies indicate a reasonable probability of economic feasibility. The latter does not appear to meet economic feasibility criteria.

Additional features included in the total framework plan, not previously included in the subbasin frameworks, include: Slackwater navigation, $3 billion; extension of the navigable waterway to Gavins Point Dam, $60 million; and channel bed lowering below three main stem dams, $30 million – a total cost of $3.09 billion.

THE BASIN PLAN

Development of a water resources plan for the Missouri River Basin depends on the resolution of problems and development of resources in the tributary drainage areas. Accordingly, the basin plan reflects a summation of tributary subbasin frameworks, together with such additional improvements on the main stem as may be required in light of the effects of the tributary developments on the Missouri River. From an unconstrained standpoint, the features of the basin framework plan, as summarized in table 100, would require incremental investments of $6.5 billion, $7.9 billion, and $10.1 billion, at 1980, 2000, and 2020 time levels, or a total of $24.5 billion. The cost-sharing analysis for the Missouri Basin is summarized in table 101.

Table 100 – FEATURES FOR FRAMEWORK PLAN – MISSOURI BASIN

Feature	Unit	Amounts 1980	2000	2020
		(Cumulative Above Current)		
SPECIFIED NON-FEDERAL PROGRAMS				
Private Ground-water Irrigation	1,000 AC	1,614	3,456	5,969
State, Local, and Private Recreation	1,000 AC	980	2,377	3,789
Private Land Conservation	1,000 AC	29,571	69,592	102,744
MODIFICATIONS OF EXISTING DEVELOPMENTS				
Irrigation System Improvements				
Ditch Consolidation	Miles	867	2,211	3,259
Ditch Lining	Miles	857	2,814	4,750
Drainage	1,000 AC	152	358	591
Reservoirs	1,000 AF	387	654	674
Fishing and Recreation Access	Number	903	1,210	1,398
National Recreation Area	1,000 AC	37	75	75
Fish Hatcheries	Number	3	4	4
Refuge Additions	Number	16	20	22
SURFACE WATER CONTROL				
Storage	1,000 AF	20,360	35,573	46,344
Local Protection	Miles	2,449	3,882	4,791
Bank Stabilization	Miles	537	1,607	2,144
Grade Stabilization	Structures	3,337	7,174	10,263
LAND DEVELOPMENT				
Recreation, Fish and Wildlife	1,000 AC	671	1,225	1,686
Group Drainage	1,000 AC	252	595	807
Surface Water Irrigation				
Federal	1,000 AC	578	1,433	2,384
Non-Federal	1,000 AC	543	1,313	2,502
Public Land Conservation	1,000 AC	2,072	7,732	11,461
ENVIRONMENTAL ENHANCEMENT				
Sewage Treatment Plants	Number	1,938	2,223	3,870
Water Supply and Treatment	1,000 AF/YR	1,087	2,046	3,703
Fish and Wildlife				
Wetlands	1,000 AC	1,146	1,183	1,219
Management Areas	1,000 AC	251	409	548
Fish Hatcheries	Number	8	10	15
Fish Impoundments	Number	88	131	188
Scenic Rivers	Miles	35	928	1,048
Special Areas	Number	35	68	69
Trails	Miles	2,475	4,490	6,240
NON-STRUCTURAL MEASURES				
Flood Plain Management				
Area	1,000 AC	879	3,816	5,773
Flood Hazard Reports	Number	106	348	612
Water Yield Increases				
Forest Management	1,000 AF	117	399	436
Precipitation Management	1,000 AF	203	564	1,270
MISSOURI RIVER IMPROVEMENTS				
Navigation Extension	Miles	---	55	55
Tailwater Dredging	Miles	---	65	65
Slackwater Navigation	Miles	---	---	811

Table 101 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY – MISSOURI BASIN

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						1,136.8		1,136.8
State & Local Recreation						3,149.4	1,376.7	1,772.7
National Recreation Area	54.2	54.2						
Private Land Conservation						3,788.0	1,894.0	1,894.0
Irrigation Rehabilitation	313.0	313.0		313.0				
Access						27.1		27.1
Refuges	18.5	18.5						
Hatcheries	3.7	2.0			1.7			
Reservoirs	19.5	19.5				85.8		85.8
Water Control and Related Land								
Single Purpose F. C.	579.8	463.8			116.0			
Other Single Purpose Res.	366.3	366.3		352.2		164.8		164.8
Grade Stabilization	243.7	194.9			48.8			
Bank Stabilization	51.8	36.4			15.4			
M. P. Reservoirs	4,241.3	(2,391.3)	(1,850.0)	(1,446.7)				
Assoc. Joint Works	569.0		(569.0)	(549.9)				
Water Quality			182.1					
Irrigation			1,099.1	1,099.1				
M & I			280.9	280.9				
Power		182.0	92.1	274.1				
Recreation		754.3	378.8	338.5				
Fish and Wildlife		8.0	384.6	4.0				
Flood Control		1,447.0	1.4					
Surface Water Irrigation	1,692.0	1,692.0		1,692.0		739.7		739.7
Group Drainage	74.3	37.5			36.8			
Public Land Conservation	62.5	62.5						
Environ. and Non-Structural								
Sewage Treatment						1,105.0	331.5	773.5
Water Supply & Treatment						1,829.7	914.9	914.8
Fish and Wildlife								
Wetlands	74.0	70.2			3.8			
Management Areas						109.0	54.9	54.1
Fish Hatcheries	16.9	8.7			8.2			
Fish Impoundments	23.1	11.7			11.4			
Scenic Rivers	12.5	12.5						
Trails	30.8	30.8						
Flood Plain Management	10.9	10.9				728.5		728.5
Forest Management	2.5	2.5						
Precip. Management	42.7	42.7						
Totals	8,503.0	5,841.9	2,419.0	4,353.8	242.1	12,863.8	4,572.0	8,291.8
Missouri River	3,090.0	3,090.0		30.0				

1965-2020 Total: 24,456.8

CHAPTER 8

ASSESSMENT OF FRAMEWORK PLAN RESPONSES TO NEEDS

The framework plan was formulated to meet projected future needs. It reflects a response to these needs within the multi-planning objectives pertinent to the basin and its individual subbasins. Accordingly, the plan was further analyzed as to its effectiveness in meeting projected needs or to achieve specified objectives. From such an evaluation and in light of possible physical and fiscal constraints, the timing for implementation of the features of the framework plan can be determined. This chapter discusses the functional outputs that can be anticipated with implementation of the framework plan, the functional inter-relationships, and the extent to which objectives are met.

RESPONSES TO FUNCTIONAL NEEDS

An analysis of functional outputs of goods and services that would be attained by implementation of the framework plan provides a measure of plan effectiveness. The plan responses are compared with projected needs and the relationships to the planning objectives determined. For purposes of uniformity, the term "needs" is used as the parameter to which responses are compared. However, as discussed in chapter 5, needs as projected in the framework study reflect many considerations, some of which do not fit the classical economic definition of the supply-demand relationships from which needs are determined.

Flood Control

Flood control requirements were expressed in terms of areas subject to flooding and projected flood damage levels, recognizing the damage reduction capability of existing improvements. The plan formulation criteria for this function, however, were not aimed at complete flood damage prevention, which is economically impracticable. Rather, the basic philosophy was to formulate a flood damage prevention program that would encompass both structural and non-structural measures; that in multiple-purpose systems, or in single-purpose projects, would be based on economic feasibility; that structural measures would be limited to those with apparent economic feasibility within the near term; that reliance would be placed on land-use controls to dampen long-term damage levels and to complement structural programs as a means for dampening residual losses from increasing significantly; and that would include flood plain land-use controls to provide for recreational outlets. However, within the concepts outlined, the extent and magnitude of the flood control features vary between subbasins. In some areas, such as the upper portion of the basin, economically feasible features for this function are possible only from incorporation with other functions which are more dominant in most multiple-purpose projects. In the lower part of the basin, where floods and flood damages are more prevalent, the flood control function becomes more dominant. The estimated areas which would be provided flood damage prevention and management, and the damages to be prevented are shown in table 102.

Estimates of flood damage levels were prepared for a number of conditions. As of the base year, 1965, average annual flood damages were estimated at about $95.5 million, of which 14 percent were urban. In the absence of projects then in existence, damage levels would have been on the order of $200 million, an indicated flood damage reduction of $104.5 million, or 52 percent. Through the projection period, 1965-2020, the damage prevention effectiveness of existing projects would average about 56 percent, but with residual flood losses of better than $152 million, $241 million, and $392 million remaining at the projection years of 1980, 2000, and 2020, respectively. As indicated in table 102, additional capability from the framework plan for both structural and non-structural measures would reduce or alleviate the residual flood losses by 43, 63, and 72 percent for the target years. Considering the size of the basin and the relatively high flood damage prevention being provided and to be provided at urban areas, the remaining or residual flood losses are mainly in agricultural areas. Additional investments, either for further control of floods or management of flood plains, are not considered warranted.

Land-use management of the flood plains in the interest of flood damage abatement can result in other benefits being realized. In the Missouri River Basin, land

Table 102 – FLOOD CONTROL RESPONSE FROM SUBBASIN FRAMEWORK PLANS – MISSOURI BASIN

Subbasin	Feature	Unit	Needs 1980	Needs 2000	Needs 2020	Plan Response: Area Protected and Managed Damages Prevented 1980	2000	2020
Upper Missouri	Structural							
	Area	1,000 AC				69	110	170
	Damages[1]	$1,000				892	2,451	5,423
	Non-Structural							
	Area	1,000 AC				2	42	74
	Damages	$1,000				139	409	821
	Total Damages	$1,000	2,887	5,220	10,007	1,031	2,860	6,244
Yellowstone	Structural							
	Area	1,000 AC				29	43	74
	Damages	$1,000				745	2,184	4,471
	Non-Structural							
	Area	1,000 AC				11	25	409
	Damages	$1,000				139	482	1,901
	Total Damages	$1,000	3,671	7,059	14,160	884	2,666	6,372
Western Dakota	Structural							
	Area	1,000 AC				42	121	151
	Damages	$1,000				681	1,983	3,538
	Non-Structural							
	Area	1,000 AC				2	37	173
	Damages	$1,000				40	391	944
	Total Damages	$1,000	4,100	6,205	12,302	721	2,374	4,482
Eastern Dakota	Structural							
	Area	1,000 AC				339	421	470
	Damages	$1,000				4,692	10,138	16,785
	Non-Structural							
	Area	1,000 AC				51	234	329
	Damages	$1,000				328	1,118	2,196
	Total Damages	$1,000	11,335	18,668	30,598	5,020	11,256	18,981
Platte-Niobrara	Structural							
	Area	1,000 AC				418	763	905
	Damages	$1,000				8,538	23,913	44,974
	Non-Structural							
	Area	1,000 AC				79	828	1,342
	Damages	$1,000				1,365	4,959	9,902
	Total Damages	$1,000	27,125	48,452	83,353	9,903	28,872	54,876
Middle Missouri	Structural							
	Area	1,000 AC				513	889	1,276
	Damages	$1,000				5,508	13,506	28,318
	Non-Structural							
	Area	1,000 AC				93	653	813
	Damages	$1,000				1,004	3,502	6,396
	Total Damages	$1,000	23,258	34,702	50,100	6,512	17,008	34,714
Kansas	Structural							
	Area	1,000 AC				552	878	1,076
	Damages	$1,000				10,967	25,067	51,992
	Non-Structural							
	Area	1,000 AC				50	427	904
	Damages	$1,000				351	1,914	4,126
	Total Damages	$1,000	30,126	44,544	67,904	11,318	26,981	56,118
Lower Missouri	Structural							
	Area	1,000 AC				1,354	1,949	2,116
	Damages	$1,000				25,576	50,138	83,511
	Non-Structural							
	Area	1,000 AC				591	1,570	1,729
	Damages	$1,000				4,267	9,770	16,536
	Total Damages	$1,000	50,033	76,420	123,836	29,843	59,908	100,047
Missouri Basin	Structural							
	Area	1,000 AC				3,316	5,174	6,238
	Damages	$1,000				57,599	129,380	239,012
	Non-Structural							
	Area	1,000 AC				879	3,816	5,773
	Damages	$1,000				7,633	22,545	42,822
	Total Damages	$1,000	152,535	241,270	392,260	65,232	151,925	281,834

Note: Area managed is partially included in area protected by structural measures.
[1] All values reflect average annual losses at indicated time levels.

Flood Control Benefits Are Typified By The Emergency-Heightened Floodwalls at Omaha in 1952

requirements, based on projected recreation demands, to be developed by the State, local, and private sectors approximate 3.5 million acres. It is estimated that about 2 million acres of flood plain land is suitable and could be developed for this purpose. In addition, about 500 thousand acres are required for wildlife management purposes of which 200 thousand acres could be developed on the flood plains. Therefore, management of land for one purpose can yield substantial benefits for another. As can be noted from table 102, 5.8 million acres were determined in need of flood plain management as a flood damage dampening device by 2020. Non-structural measures in urban areas and the change in land use for purposes described account for about 2.3 million acres. The remaining 3.5 million acres would be in rural areas. The management of these lands would be regulated especially as to new structures and high damage value uses. Regulation would include those agricultural, recreational, and wildlife uses which could minimize flood losses.

By the very nature of the planning criteria and the manner in which the flood control function was formulated, the extent and magnitude of the plan features for flood control are in response to national efficiency as well as regional objectives. They partially meet the quality-of-the-environment objective. Since many facets of environmental quality are intuitive, the extent to which structural flood control measures meet this objective depends on the viewpoint. From one viewpoint, a channel improvement might be regarded as unacceptable and detrimental to the environment and alternative solutions would be sought regardless of economic costs. From another viewpoint, people subjected to the misery and economic loss from a flood probably would regard its control as a substantial improvement of their environment. In view of the plan features discussed herein as well as in the preceding chapter, it would appear that a reasonable flood control program has been formulated, generally responsibe to all objectives.

With respect to water use, flood control is generally nonconsumptive and only those losses associated with reservoir evaporation are attributed to this function. Accordingly, it is compatible with all other functional developments. For many of the reservoir systems outlined in the subbasin frameworks it is an indispensable component since regulation of high flows often is required for the systems to perform efficiently and to serve the purposes intended.

Erosion Control

Erosion problems in the Missouri River Basin have been segregated and quantified as streambank and gully erosion. In spite of a considerable lack of basic data and the reconnaissance character of the erosion study, a quantification of streambank miles subjected to erosion and areas affected by gully erosion was made. The extent to which control structures would be required was based on a generalized study of economic feasibility, similar to the flood control function. The subbasin frameworks, therefore, include plan features for this functional item which have a reasonable expectancy of being economically justified. Table 103 presents a comparison between the erosion control potential and the streambank and gully erosion control response from the frameworks.

Erosion Seriously Damages The Agricultural Land Resource

The outputs summarized in Table 103 reflect bank miles and areas protected and damages prevented. In some areas of the basin, such as the Middle Missouri Subbasin, control of erosion is simply not a matter of just preventing land destruction to retain the economic value of such land. Rather, the reduction in sediment transport permits more economical storage reservoirs, in terms of useful life, and provides for better water quality — thus improving environmental stream characteristics, especially for fishing. These control measures, together with land conservation measures described in subsequent sections of this chapter, thus become essential elements of other features of certain subbasin plans. In the Middle Missouri Subbasin, for example, future sediment reductions ranging from 10 to 40 percent of the current sediment yields were used in formulation of the reservoir systems. This means that from a timing standpoint, erosion control measures, including land conservation should preceed or be installed concurrent with reservoir construction. In other subbasins, erosion control measures do not have the close interrelationship described, and thus are generally single-purpose oriented and must be economically justified as such.

The outputs from the erosion control function are responsible to national and regional objectives. They generally meet environmental quality objectives, except that questions have been raised as to the aesthetics of certain erosion control structures. In the future, consideration should be given during planning, design, and construction to develop structures that are aesthetically compatible with the environment. In some instances this may not be possible, but the general overall environmental characteristics probably will not be significantly degraded as to preclude construction of such structures.

Land Conservation

Land conservation on the watersheds of the basin includes those actions taken to ameliorate wind and water erosion, to remove excess water from agricultural lands, to develop livestock water supplies, and to accomplish other land use and conservation treatment for efficient production and preservation of the land base. Land conservation practices have been carried out in the past in both the private sector and on federally owned lands. In the private sector, about 41 percent, or 110 million acres, are adequately treated and managed. The remaining potential for conservation practices approximates 165 million acres. On federally owned lands, about 29 million of the 43 million acres in this category are adequately treated leaving a potential of nearly 14 million acres for treatment. Table 104 summarizes this functional category in terms of projected accomplishments that can be realized from this program.

Aside from the need to conserve and stabilize the land base, which allows for investments to be made to increase agricultural production and efficiency, the erosion control features become significantly important in those areas where a major interrelationship exists between erosion and other water uses. This was described in the preceding paragraphs. It should be noted, however, that further improvements in the watershed conservation program should be sought in the future.

With the significantly increased livestock production projected for the future, additional water developments

Table 103 – STREAMBANK AND GULLY EROSION RESPONSE FROM SUBBASIN FRAMEWORK PLANS
MISSOURI BASIN

						Plan Response		
			Needs[1]			Bank-Miles and Area Protected Damages Prevented[1]		
Subbasin	**Feature**	**Unit**	**1980**	**2000**	**2020**	**1980**	**2000**	**2020**
Upper Missouri	Bank Erosion							
	Bank-Miles	Miles	2,600	2,600	2,600	36	108	144
	Damages	$1,000	660	930	1,190	610	810	1,080
Yellowstone	Bank Erosion							
	Bank-Miles	Miles	8,300	8,300	8,300	28	83	111
	Damages	$1,000	620	870	1,220	390	550	770
	Gully Erosion							
	Area	1,000 AC	39	39	39	1	5	14
	Damages	$1,000	467	756	1,245	12	97	447
Western Dakota	Bank Erosion							
	Bank-Miles	Miles	11,700	11,700	11,700	33	100	133
	Damages	$1,000	620	830	1,110	490	660	880
	Gully Erosion							
	Area	1,000 AC	17	17	17	3	7	7
	Damages	$1,000	53	72	96	16	41	64
Eastern Dakota	Bank Erosion							
	Bank-Miles	Miles	3,800	3,800	3,800	3	9	12
	Damages	$1,000	610	830	1,120	100	140	190
	Gully Erosion							
	Area	1,000 AC	126	126	126	67	110	117
	Damages	$1,000	815	1,108	1,497	585	972	1,310
Platte-Niobrara	Bank Erosion							
	Bank-Miles	Miles	11,100	11,100	11,100	27	80	107
	Damages	$1,000	800	1,100	1,560	540	740	1,040
	Gully Erosion							
	Area	1,000 AC	97	97	97	8	22	36
	Damages	$1,000	907	1,321	1,976	162	422	707
Middle Missouri	Bank Erosion							
	Bank-Miles	Miles	4,900	4,900	4,900	325	973	1,298
	Damages	$1,000	1,540	2,130	2,950	1,230	1,690	2,320
	Gully Erosion							
	Area	1,000 AC	1,053	1,053	1,053	210	446	622
	Damages	$1,000	12,700	17,759	24,953	5,911	13,069	18,442
Kansas	Bank Erosion							
	Bank-Miles	Miles	5,200	5,200	5,200	71	211	282
	Damages	$1,000	1,800	2,410	3,220	1,490	1,990	2,650
	Gully Erosion							
	Area	1,000 AC	169	169	169	66	82	117
	Damages	$1,000	1,600	2,362	3,570	727	1,127	1,973
Lower Missouri	Bank Erosion							
	Bank-Miles	Miles	5,100	5,100	5,100	14	43	57
	Damages	$1,000	650	900	1,230	130	170	230
	Gully Erosion							
	Area	1,000 AC	540	540	540	189	273	296
	Damages	$1,000	6,869	10,471	17,029	3,474	6,532	11,266
Missouri Basin	Bank Erosion							
	Bank-Miles	Miles	52,700	52,700	52,700	537	1,607	2,144
	Damages	$1,000	7,300	10,000	13,600	4,980	6,750	9,160
	Gully Erosion							
	Area	1,000 AC	2,041	2,041	2,041	544	945	1,209
	Damages	$1,000	23,411	33,849	50,366	10,887	22,260	34,209

[1] All values reflect average annual losses at indicated time levels.

Table 104 – LAND CONSERVATION RESPONSE FROM SUBBASIN FRAMEWORK PLANS
MISSOURI BASIN

Subbasin	Feature	Unit	Needs 1980	Needs 2000	Needs 2020	Plan Response Area Treated 1980	Plan Response Area Treated 2000	Plan Response Area Treated 2020
			(Cumulative Above Current)					
Upper Missouri	Land Conservation							
	Private	1,000 AC	23,431	23,431	23,431	4,587	10,243	15,596
	Public	1,000 AC	4,710	4,710	4,710	773	2,712	3,870
	Total	1,000 AC	28,141	28,141	28,141	5,360	12,955	19,466
Yellowstone	Land Conservation							
	Private	1,000 AC	18,161	18,161	18,161	3,232	7,455	12,165
	Public	1,000 AC	4,431	4,431	4,431	778	2,723	3,891
	Total	1,000 AC	22,592	22,592	22,592	4,010	10,178	16,056
Western Dakota	Land Conservation							
	Private	1,000 AC	22,604	22,604	22,604	4,050	10,310	14,054
	Public	1,000 AC	2,143	2,143	2,143	108	1,134	1,620
	Total	1,000 AC	24,747	24,747	24,747	4,158	11,444	15,674
Eastern Dakota	Land Conservation							
	Private	1,000 AC	21,501	21,501	21,501	3,543	10,763	15,100
	Public	1,000 AC	43	43	43	2	12	18
	Total	1,000 AC	21,544	21,544	21,544	3,545	10,775	15,118
Platte-Niobrara	Land Conservation							
	Private	1,000 AC	30,738	30,738	30,738	6,188	13,138	19,485
	Public	1,000 AC	2,158	2,158	2,158	387	1,062	1,936
	Total	1,000 AC	32,896	32,896	32,896	6,575	14,200	21,421
Middle Missouri	Land Conservation							
	Private	1,000 AC	9,658	9,658	9,658	1,491	3,289	5,386
	Public	1,000 AC	2	2	2	0	2	2
	Total	1,000 AC	9,660	9,660	9,660	1,491	3,291	5,388
Kansas	Land Conservation							
	Private	1,000 AC	23,949	23,949	23,949	5,035	10,700	15,308
	Public	1,000 AC	144	144	144	18	63	91
	Total	1,000 AC	24,093	24,093	24,093	5,053	10,763	15,399
Lower Missouri	Land Conservation							
	Private	1,000 AC	15,095	15,095	15,095	1,445	3,694	5,650
	Public	1,000 AC	48	48	48	6	24	33
	Total	1,000 AC	15,143	15,143	15,143	1,451	3,718	5,683
Missouri Basin	Land Conservation							
	Private	1,000 AC	165,137	165,137	165,137	29,571	69,592	102,744
	Public	1,000 AC	13,679	13,679	13,679	2,072	7,732	11,461
	Total	1,000 AC	178,816	178,816	178,816	31,643	77,324	114,205

Stock Ponds Are A Part Of A Total Conservation Program

will be required. In order to supply the consumptive needs of livestock and to further improve the distribution of grazing, an additional 116,000 livestock water ponds will be needed. Total water use will double. Future development and management practices emphasize efficient water use in order to minimize the gross present and future livestock water requirements.

Group Drainage Systems

There are about 15.3 million acres of agricultural land in the basin with excess moisture problems. Preliminary studies indicate that 30 percent, or about 4.6 million acres, are adequately drained, and about 5.6 million acres are potentially unsuitable for efficient production, even if they were drained. The remaining 5.1 million

acres have a potential for reducing risk and instability and increasing agricultural production and efficiency through drainage improvement. This excludes some 706,000 acres of land requiring drainage and to be accommodated as a part of the improvement of existing irrigation systems. Most of the drainage improvement to agricultural lands will be carried out in the private sector in conjunction with conservation and management programs outlined in preceding paragraphs, while about 2 million acres would require project-type drainage measures. During plan formulation, studies were made to determine the portion of the total potential for drainage which may be developed through public or group systems. The criterion here was the magnitude of the problem in various areas of the basin and the outlook for economic feasibility. Table 105 summarizes the magnitude of the group drainage systems which appear desirable and are economically feasible.

Drainage Increases Land Use Efficiency

As indicated by table 105, economically feasible drainage systems in the basin constitute a small part of the potential for drainage and are generally responsive to the national and regional objectives. The economically feasible group or project drainage included in the framework plan is for economic efficiency. Therefore, it is considered that no significant degradation to the natural environment would occur with implementation of these features of the plan.

Table 105 — GROUP DRAINAGE SYSTEMS RESPONSE FROM SUBBASIN FRAMEWORK PLANS MISSOURI BASIN

Subbasin	Group Drainage Potential 2020	Plan Response Area Drained 1980	2000	2020
	(Thousand Acres Cumulative Above Current)			
Upper Missouri	0	0	0	0
Yellowstone	0	0	0	0
Western Dakota	19	8	9	9
Eastern Dakota	501	6	118	118
Platte-Niobrara	548	160	233	350
Middle Missouri	490	29	134	194
Kansas	142	9	31	36
Lower Missouri	300	40	70	100
Missouri Basin	2,000	252	595	807

Irrigation

Continuing the present trend, it is anticipated that there will be a continued demand and need to expand irrigation throughout the basin within the limits of economic and physical feasibility. Further development contemplated under the framework plan, as reflected in table 106, includes the rehabilitation and improvement of existing irrigation systems, together with new developments using individual and system ground-water and surface-water supplies.

Rehabilitation and improvement of existing irrigation systems would be undertaken to overcome inadequate water supplies, inefficient delivery facilities, and to add drainage works to reclaim lands with excess moisture. Practically all of this would be on the older systems serving about 5.8 million acres of land. This would have three general effects: (1) conserve water supplies and further reduce production costs; (2) increase agricultural production for full irrigation capability; and (3) reduce annual operation and maintenance costs. All improvements would be consistent with statutory rights governing the use of water on these lands. The overall effect by 2020 would be equivalent to 499,000 acres of new irrigation production capability, though actually no new acreage would be irrigated.

Of the 10.9 million additional acres to be developed, 6.0 million acres would be developed with ground-water supplies and 4.9 million acres with surface-water supplies. Of the surface water developments, 2.5 million acres would be developed by the private sector and the

Table 106 – IRRIGATION DEVELOPMENT RESPONSE FROM SUBBASIN FRAMEWORK PLANS
MISSOURI BASIN

Subbasin	Feature	Current Irrigated Area	Projected Requirements and Response 1980	2000	2020
			(Thousand Acres Cumulative Above Current)		
Upper Missouri	Rehabilitation & Improvement[1]		(47)	(109)	(153)
	New Ground Water		0	30	55
	New Surface Water		192	377	495
		1,102	192	407	550
Yellowstone	Rehabilitation & Improvement[1]		(33)	(56)	(68)
	New Ground Water		7	22	29
	New Surface Water		183	431	608
		1,188	190	453	637
Western Dakota	Rehabilitation & Improvement[1]		(1)	(2)	(5)
	New Ground Water		7	39	119
	New Surface Water		149	327	643
		209	156	366	762
Eastern Dakota	Rehabilitation & Improvement[1]		(0)	(0)	(0)
	New Ground Water		90	225	442
	New Surface Water		139	526	1,285
		119	229	751	1,727
Platte-Niobrara	Rehabilitation & Improvement[1]		(115)	(187)	(246)
	New Ground Water		534	1,036	1,732
	New Surface Water		235	461	629
		2,986	769	1,497	2,361
Middle Missouri	Rehabilitation & Improvement[1]		(0)	(0)	(0)
	New Ground Water		218	754	1,282
	New Surface Water		21	91	349
		103	239	845	1,631
Kansas	Rehabilitation & Improvement[1]		(0)	(14)	(27)
	New Ground Water		650	1,084	1,898
	New Surface Water		80	210	319
		1,703	730	1,294	2,217
Lower Missouri	Rehabilitation & Improvement[1]		(0)	(0)	(0)
	New Ground Water		108	266	412
	New Surface Water		122	323	558
		5	230	589	970
Missouri Basin	Rehabilitation & Improvement[1]		(196)	(368)	(499)
	New Ground Water		1,614	3,456	5,969
	New Surface Water		1,121	2,746	4,886[2]
		7,415	2,735	6,202	10,855

[1]New acreage equivalent to reflect added production from lands now irrigated but requiring supplemental water, improved delivery, or drainage.
[2]Includes 2.5 million acres of private development and 2.4 million acres of public project-type development.

remainder by public project-type improvements. Reflecting the variation in water resource availability, there is a wide difference in magnitude of planned development for ground-water and surface-water utilization among the subbasins. Not apparent is the planned development and use of surface water supplies under conjunctive-use systems where the deep percolating surface irrigation waters would firm up and sustain the ground-water supply for well irrigation on over 500,000 acres of land now experiencing declining ground-water levels. Further, much of the designated ground-water supply for private use would be obtained from alluvia of principal streams and tributaries such as the Missouri, Platte, and other rivers, where a part of the recharge is, or will be, from streamflow whose regimen will be improved by planned reservoir regulation. Also, an undetermined amount of projected private pumping development from surface streamflow is contingent in some degree upon planned multipurpose reservoirs for a dependable water supply. The agricultural production response for the irrigation features, as well as other features of the framework plan is presented in a later section of this chapter.

With few exceptions, the surface-water irrigation developments require reservoir storage and extensive diversion and distribution systems for water delivery. For such major systems, generally 10 to 20 years time elapses between the initial detailed studies and the

realization of full production capability — thus considerable lead time is required in planning for the production response.

Irrigation Puts The Finishing Touch To Crops Nearing Maturity

Fish and Wildlife

The potentials and demands for fish and wildlife were expressed in terms of days of use for fishing and hunting and also in terms of the breeding and production of various species of fish and wildlife. With respect to commercial fisheries, the estimated supply potential exceeds projected intraregional demands and any major increase in use will depend on markets outside the region. This cannot be achieved on a food fish basis alone, and will require large scale production of industrial fish. The existing capacity, together with additional water acreages developed for other purposes, should be sufficient to meet possible future commercial fishery needs, provided that technological, economic, institutional, and management factors lead to a viable commercial fisheries industry.

As was discussed in chapter 5, the projected demands for fishing and hunting as recreational pursuits include "latent" demands which can be satisfied if quality opportunities are made available at key locations, especially near urban centers. In the upper part of the basin, fishing opportunities (or resources) generally exceed demands now and in the future. Hunting capabilities in these same areas appear to be sufficient to meet indicated demands to about the year 2000. In the lower part of the basin, the opposite situation is encountered where total demands are significantly greater than available opportunities and capacities. This merely reflects the imbalance of basinwide demands versus capacity. The fish and wildlife features of the subbasin frameworks were developed with a view toward correcting such imbalances and to meet the projected subbasin demands within physical and other constraints that affect their development and management opportunities. Table 107 presents, by subbasins, the projected fishing and hunting needs and the framework plan responses.

The goods and services for the fish and wildlife function are derived from a number of developmental and managerial features of the subbasin frameworks. These include reservoirs, low-flow augmentation of streams, water quality improvements, and the addition of fish hatcheries, refuges, management areas, and preservation of wetland areas. This function has a close interrelationship with many other water and related land resource functions. Thus, a significant portion of its output is dependent on the development of multiple-purpose or single-purpose reservoir systems, preservation and maintenance of quality streamflows, and pollution abatement measures.

As is readily apparent from table 107, the projected fishing demands are generally met in most subbasins. In some, the output greatly exceeds the needs and reflects a capability to supply or support fishing demands not only from within the subbasin, but also the Missouri Basin and other regions. In two subbasins, the output is slightly less than projected demands and they can support only the resident-visitor mix inherent in the demands projection. Because of physical, legal, and other constraints, projected hunting needs cannot be met except in the Upper Missouri, Yellowstone, Western Dakota, and Kansas subbasins. In general, the percentage of hunting needs met over the future will decline and for the basin as a whole would be slightly greater than 50 percent by the year 2020. Hunting capacity is dependent on the private sector, primarily agriculture, to provide the hunting opportunities. Thus, certain actions involving legal and institutional changes and certain economic policies of the hunting public could further increase the capacity and opportunities for meeting hunting demands. These are discussed in chapter 9.

The fish and wildlife features incorporated in the subbasin frameworks are generally responsive to the quality of the environment objective. In some areas, it is physically or legally impossible to maximize fish and wildlife in response to the environmental objective. In others, developments to meet other objectives were selected which, although not completely detrimental to fish and wildlife, did not maximize the output for that function. Other than these limitations, the fish and wildlife features and outputs should meet a significant portion of the environmental objective.

Table 107 – FISH AND WILDLIFE RESPONSE FROM SUBBASIN FRAMEWORK PLANS
MISSOURI BASIN

Subbasin	Feature	Unit	Needs 1980	Needs 2000	Needs 2020	Plan Response 1980	Plan Response 2000	Plan Response 2020
			(Cumulative Above Current)					
Upper Missouri	Fishing	1,000 F.D.	-3,330[1]	-2,815	-1,893	1,757	2,599	3,482
	Hunting	1,000 H.D.	-546	-160	96	29	133	233
Yellowstone	Fishing	1,000 F.D.	-2,662	-1,978	-705	130	336	452
	Hunting	1,000 H.D.	-259	27	437	15	54	472
Western Dakota	Fishing	1,000 F.D.	-2,451	-1,967	-1,239	342	655	1,196
	Hunting	1,000 H.D.	-849	-584	-285	51	112	133
Eastern Dakota	Fishing	1,000 F.D.	-3,800	-3,169	-2,382	990	1,678	2,292
	Hunting	1,000 H.D.	-785	199	1,160	524	527	642
Platte-Niobrara	Fishing	1,000 F.D.	241	5,344	13,182	3,403	5,913	9,247
	Hunting	1,000 H.D.	4,265	7,380	10,886	2,207	4,214	6,620
Middle Missouri	Fishing	1,000 F.D.	1,157	2,118	3,511	4,929	8,080	12,955
	Hunting	1,000 H.D.	684	1,416	2,441	179	277	340
Kansas	Fishing	1,000 F.D.	-147	920	2,288	1,467	2,384	3,366
	Hunting	1,000 H.D.	684	1,507	2,541	637	1,492	2,541
Lower Missouri	Fishing	1,000 F.D.	5,482	9,853	15,401	4,680	9,276	14,831
	Hunting	1,000 H.D.	2,465	5,049	8,844	1,151	2,511	3,564
Missouri Basin	Fishing	1,000 F.D.	-5,510	8,306	28,163	17,698	30,921	47,821
	Hunting	1,000 H.D.	5,659	14,834	26,120	4,793	9,320	14,545

[1]Negative values reflect excess capacity for meeting needs.

Management Areas Provide Habitat For Game

From the nature of the plan formulation process, this functional output is generally *on the order of regional* desire and capability. From a national efficiency objective, and from a regional economic objective for that matter, those features which produce surpluses — such as fishing capacity — would appear not to warrant investments either regionally or nationally, since there would be no increased return. However, such capability could provide a base for an expansion in tourism and add to the regional economy, with some increases to national income.

Outdoor Recreation

Although treated separately, fishing and hunting are activities that add to the total outdoor recreation activity. For study purposes, these were segregated, but during plan formulation the joint use of certain developments, such as recreation areas at a reservoir, was recognized, and duplication avoided. Other environmental enhancements such as scenic river preservation, special use areas, and trail development were treated as *outdoor recreation* items, but also have intrinsic fish and wildlife values.

Although recreation demands and needs are expressed in terms of recreation-days, which reflect a mix of recreational activity, further delineation also was made in terms of water area, developed land area, and undeveloped land area required to meet the total recreation needs. Such translation from use to physical requirements was based on a good quality recreation environment. Moreover, a considerable portion of total recreational development in the future, as has been the case in the past, will take place through State, local, and private sectors. The outputs from the subbasin frameworks, as summarized in *table 108*, reflect those values that can reasonably be expected to obtain from public works projects, generally authorized and funded by the Federal Government, and those developments to be carried out by the State, local, and private sectors, often with almost equally significant Federal funding and grants.

Recreation Outlets In The Private Sector Are Significant

Table 108 — OUTDOOR RECREATION RESPONSE FROM SUBBASIN FRAMEWORK PLANS
MISSOURI BASIN

Subbasin	Feature	Unit	Needs 1980	Needs 2000	Needs 2020	Plan Response 1980	Plan Response 2000	Plan Response 2020
			(Cumulative Above Current)					
Upper Missouri	Multi-Purpose Development	1,000 R.D.				1,142	2,225	5,895
	State, Local & Private	1,000 R.D.				7,098	14,681	22,321
	Total	1,000 R.D.	8,241	18,419	28,716	8,240	16,906	28,216
Yellowstone	Multi-Purpose Development	1,000 R.D.				5,740	14,510	16,612
	State, Local & Private	1,000 R.D.				3,181	7,420	12,832
	Total	1,000 R.D.	6,070	15,488	27,698	8,921	21,930	29,444
Western Dakota	Multi-Purpose Development	1,000 R.D.				1,543	3,480	5,868
	State, Local & Private	1,000 R.D				2,516	5,677	9,575
	Total	1,000 R.D.	3,104	8,202	14,488	4,059	9,157	15,443
Eastern Dakota	Multi-Purpose Development	1,000 R.D.				3,490	11,610	16,760
	State, Local & Private	1,000 R.D.				3,570	8,260	14,440
	Total	1,000 R.D.	7,082	15,680	26,779	7,060	19,870	31,200
Platte-Niobrara	Multi-Purpose Development	1,000 R.D.				13,298	27,157	47,616
	State, Local & Private	1,000 R.D.				13,121	26,524	54,428
	Total	1,000 R.D.	26,203	64,179	120,865	26,419	53,681	102,044
Middle Missouri	Multi-Purpose Development	1,000 R.D.				4,815	9,361	13,347
	State, Local & Private	1,000 R.D.				4,374	14,631	23,058
	Total	1,000 R.D.	12,547	26,305	43,306	9,189	23,992	36,405
Kansas	Multi-Purpose Development	1,000 R.D.				4,851	10,936	18,153
	State, Local & Private	1,000 R.D.				3,277	7,405	12,290
	Total	1,000 R.D.	8,152	18,379	30,508	8,128	18,341	30,443
Lower Missouri	Multi-Purpose Development	1,000 R.D.				11,508	17,598	31,137
	State, Local & Private	1,000 R.D.				9,812	23,320	41,269
	Total	1,000 R.D.	18,531	40,910	72,406	21,320	40,918	72,406
Missouri Basin	Multi-Purpose Development	1,000 R.D.				46,387	96,877	155,388
	State, Local & Private	1,000 R.D.				46,949	107,918	190,213
	Total	1,000 R.D.	89,930	207,562	364,766	93,336	204,795	345,601

In addition to the traditional outdoor recreation function previously outlined, the subbasin frameworks include scenic rivers, spacial use areas of major significance, and trail development features for environmental enhancement purposes. Other than for scenic rivers, the extent to which these developments are implemented will depend, not on overcoming conflicts in water and land use, but on public acceptance. Scenic rivers preservation, on the other hand, does conflict with some developmental opportunities. However, it should be pointed out that from a regional standpoint almost 90 percent of the delineated scenic river potential has been included in the framework plans. Therefore, the degree of conflict could be considered relatively minor. Table 109 presents the extent to which projected environmental features would be implemented.

The features outlined are responsive to the multiple objectives of the study. They are in consonance with the environmental objective and a major portion of the regional objective. However, the extent to which national efficiency gains, and to some extent regional economic gains, would be realized is unknown. More detailed studies relative to the net income gains from recreation developments are needed in order that

The Niobrara River Provides Quality Scenery

Table 109 – OTHER ENVIRONMENTAL ENHANCEMENT RESPONSES FROM SUBBASIN FRAMEWORK PLANS MISSOURI BASIN

Subbasin	Feature	Unit	Needs 1980	Needs 2000	Needs 2020	Plan Response 1980	Plan Response 2000	Plan Response 2020
			(Cumulative Above Current)					
Upper Missouri	Scenic Rivers	Miles	375	375	375	0	135	255
	Special Use Areas	Number	8	8	8	4	8	8
	Trails	Miles	1,180	1,180	1,180	815	1,180	1,180
Yellowstone	Scenic Rivers	Miles	315	315	315	0	315	315
	Special Use Areas	Number	2	2	2	0	1	2
	Trails	Miles	800	800	800	450	800	800
Western Dakota	Special Use Areas	Number	17	17	17	9	17	17
	Trails	Miles	390	390	390	195	390	390
Eastern Dakota	Special Use Areas	Number	4	4	4	2	4	4
	Trails	Miles	620	620	620	390	620	620
Platte-Niobrara	Scenic Rivers	Miles	160	160	160	0	120	120
	Special Use Areas	Number	21	21	21	11	21	21
	Trails	Miles	1,775	1,775	1,775	350	475	1,775
Middle Missouri	Special Use Areas	Number	2	2	2	1	2	2
	Trails	Miles	375	375	375	0	225	375
Kansas	Special Use Ares	Number	15	15	15	8	15	15
	Trails	Miles	750	750	750	275	450	750
Lower Missouri	Scenic Rivers	Miles	358	358	358	35	358	358
	Trails	Miles	350	350	350	0	350	350
Missouri Basin	Scenic Rivers	Miles	1,208	1,208	1,208	35	928	1,048
	Special Use Areas	Number	69	69	69	35	68	69
	Trails	Miles	6,240	6,240	6,240	2,475	4,490	6,240

justified investments can be ascertained and an evaluation of the capability of all sectors to finance such investments on a timely basis determined.

Electric Power

Future investments by the public or private sectors for the generation of electricity will be made primarily in accordance with economic considerations. As such, developments required are economically feasible under the concepts of both the national and regional objectives. Since most, if not all, future power generation in the basin will be thermal, the only questions are availability of water for cooling and the effects on the environment. The framework plan considers that cooling water requirements will be met in total, and that necessary steps will be taken to insure that temperature quality standards will be fulfilled. For those areas where water quantity will be limited and thermal pollution would otherwise be expected, it is assumed that the consumer will pay the costs for such measures as offstream cooling ponds or cooling towers to conserve water and to maintain water quality standards.

Some potentials for future hydropower development are included in the plan. However, the capacity envisioned would be primarily for peaking purposes and for integration with base load thermal plants. The hydro-power also would result in national and regional efficiency gains and should have no detrimental environmental effects. Table 110 summarizes the physical plant requirements in support of future requirements for electric power.

Water Supply and Treatment

The subbasin framework plans include those developments required to provide water for municipal, industrial, rural domestic, mineral processing, thermal-electric cooling, and irrigation. Sufficient quantities of water are included in multiple-purpose reservoir systems or will be developed through single-purpose systems, including ground water, to completely meet the projected needs for all uses cited, within tolerable shortage limits and practicable levels of treatment adopted for intended uses. Table 111 summarizes the water withdrawals for the purposes cited.

Water Quality

Discussions of projected treatment needs for water quality, criteria for streamflow augmentation to maintain stream quality standards, and mention of some functional interrelationships relative to water quality have been presented previously. The following paragraphs discuss and present quantitative values as to the results that can be expected from certain features of the

Table 110 – ELECTRIC POWER RESPONSE FROM SUBBASIN FRAMEWORK PLANS MISSOURI BASIN

Subbasin	Feature	Unit	Needs 1980	Needs 2000	Needs 2020	Plan Response 1980	Plan Response 2000	Plan Response 2020
			(Cumulative Above Current)					
Upper Missouri	Installed Capacity							
	Hydro	MW	1,250	1,250	1,250	400	400	400
	Thermal	MW	855	3,285	9,745	1,705	4,135	10,595
	Total	MW	2,105	4,535	10,995	2,105	4,535	10,995
Yellowstone	Installed Capacity							
	Hydro	MW	760	760	760	250	250	250
	Thermal	MW	1,661	7,138	18,653	2,171	7,648	19,163
	Total	MW	2,421	7,898	19,413	2,421	7,898	19,413
Western Dakota	Installed Capacity							
	Hydro	MW	175	175	175	0	0	0
	Thermal	MW	1,212	5,012	12,852	1,387	5,187	13,027
	Total	MW	1,387	5,187	13,027	1,387	5,187	13,027
Eastern Dakota	Installed Capacity							
	Thermal	MW	654	3,243	7,645	654	3,243	7,645
Platte-Niobrara	Installed Capacity							
	Hydro	MW	764	764	764	903	1,903	2,253
	Thermal	MW	2,134	13,419	25,838	1,995	12,280	24,349
	Total	MW	2,898	14,183	26,602	2,898	14,183	26,602
Middle Missouri	Installed Capacity							
	Thermal	MW	2,309	11,416	20,598	2,309	11,416	20,598
Kansas	Installed Capacity							
	Thermal	MW	1,791	5,987	10,356	1,791	5,987	10,356
Lower Missouri	Installed Capacity							
	Hydro	MW	318	318	318	35	35	35
	Thermal	MW	2,318	13,230	26,103	2,601	13,513	26,386
	Total	MW	2,636	13,548	26,421	2,636	13,548	26,421
Missouri Basin	Installed Capacity							
	Hydro	MW	3,267	3,267	3,267	1,588	2,588	2,938
	Thermal	MW	12,934	62,730	131,790	14,613	63,409	132,119
	Total	MW	16,201	65,997	135,057	16,201	65,997	135,057

Table 111 – WATER SUPPLY RESPONSE FROM SUBBASIN FRAMEWORK PLANS MISSOURI BASIN

Subbasin	Water Withdrawals to Meet Needs[1]											
	M&I, Mineral, and Rural Domestic			Thermal Cooling			Irrigation			Livestock		
	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
	(Thousand Acre-Feet/Year Cumulative Above Current)											
Upper Missouri	16	51	77	159	445	455	666	1,354	1,780	13	25	44
Yellowstone	454	635	1,085	293	706	778	652	1,502	2,124	11	24	41
Western Dakota	23	44	74	249	313	349	521	1,132	2,106	19	38	65
Eastern Dakota	49	90	136	182	415	684	416	1,261	2,979	24	53	92
Platte-Niobrara	234	537	954	74	-154	-252	1,746	3,179	4,706	58	117	187
Middle Missouri	125	227	373	273	560	757	240	846	1,725	36	78	136
Kansas	37	95	185	-4	16	33	1,200	2,079	3,660	25	56	100
Lower Missouri	149	367	819	172	277	350	139	358	591	34	73	129
Missouri Basin	1,087	2,046	3,703	1,398	2,578	3,154	5,580	11,711	19,671	220	464	794

[1] All needs met within tolerable shortage limits.

framework plans and an evaluation of the impact of all subbasin framework developments on water quality.

Each use of the basin's land and water resources has an effect on some element of water quality. The sources of potential organic pollution can be classified as municipal wastes, industrial wastes discharged separate from municipal systems, and agricultural wastes which include livestock feeding and residual chemicals wastes carried to the streams by surface runoff. The organic waste loadings were expressed in terms of population equivalents (P.E.) regardless of the waste source.

Feedlot Wastes Are A Problem

A potential major source of organic wastes will be from agricultural operations, particularly livestock feedlots. Runoff, other than from feedlots, was not analyzed from a pollution standpoint, because of data limitations. Projections to 2020 indicate that about 9 million cattle would be fed in lots with 300 head or more. The subbasin framework plans do not include control mechanisms, management programs, or costs for effective handling of this potential major source of pollution. The development of structural and management systems for such control is in its infancy although a coordinated local, State, and Federal approach to this emerging problem is anticipated. Various states in the basin have already initiated registration programs for feedlots and it is assumed that the States and industry will take the leadership in minimizing the effects of agricultural pollutants.

With respect to the municipal and associated industrial sources of organic pollution, the frameworks do include facilities and measures for water quality control in accordance with criteria outlined in chapter 6. Table 112 presents the effectiveness of sewage treatment measures for pollution abatement and the extent of streamflow regulation included in the subbasin frameworks which would provide for meeting State water quality stream standards.

Table 112 – WATER QUALITY RESPONSE FROM SUBBASIN FRAMEWORK PLANS
MISSOURI BASIN

Subbasin	*Feature*	*Unit*	Needs *1980*	Needs *2000*	Needs *2020*	Plan Response *1980*	Plan Response *2000*	Plan Response *2020*
			(Cumulative Above Current)					
Upper Missouri	Sewage Treatment[1]	1,000 P.E.	372	602	832	282	519	779
	Streamflow Regulation	Miles				104	226	226
Yellowstone	Sewage Treatment	1,000 P.E.	296	491	686	238	433	647
Western Dakota	Sewage Treatment	1,000 P.E.	449	689	989	368	611	935
	Streamflow Regulation	Miles				20	200	230
Eastern Dakota	Sewage Treatment	1,000 P.E.	1,099	1,659	2,219	919	1,483	2,103
	Streamflow Regulation	Miles				255	864	864
Platte-Niobrara	Sewage Treatment	1,000 P.E.	6,020	12,220	22,260	4,460	10,560	20,928
	Streamflow Regulation	Miles				140	250	290
Middle Missouri	Sewage Treatment	1,000 P.E.	4,068	5,958	6,268	3,168	5,169	5,858
	Streamflow Regulation	Miles				780	1,110	1,490
Kansas	Sewage Treatment	1,000 P.E.	945	1,575	2,295	709	1,355	2,149
	Streamflow Regulation	Miles				607	1,080	1,333
Lower Missouri	Sewage Treatment	1,000 P.E.	2,225	4,225	7,100	1,644	3,637	6,662
	Streamflow Regulation	Miles				577	1,060	1,060
Missouri Basin	Sewage Treatment	1,000 P.E.	15,474	27,419	42,649	11,788	23,767	40,061
	Population Served[2]	1,000				8,982	13,363	18,840
	Streamflow Regulation	Miles				2,463	4,790	5,483

[1]Sewage Treatment objectives to provide 85, 90 and 95 percent BOD removal adopted for this study.
[2]Includes present population.

As was described previously, streamflow temperature control is needed for environmental purposes. Because of physical and economic constraints, the subbasin framework plans do not in some instances provide sufficient water for flow-through cooling to hold temperatures within State water quality standards. However, off-stream cooling could be provided thus minimizing temperature quality problems.

An evaluation of all uses of water as envisioned in the subbasin frameworks must consider also the problem of inorganic wastes. All flowing or percolating water contains dissolved salts picked up from the soil and rocks of the earth's mantle. The soils of the high plains area in western portions of North Dakota, South Dakota, Nebraska, and Kansas make major contributions to the dissolved solids build-up of surface waters. Since

ground waters of these areas are highly mineralized, pumped water or flowing springs also increase the total dissolved solids (TDS) in the surface waters.

Salt concentrations (TDS) are increased when there is a consumptive use of water without an accompanying use of the salt. For example, in irrigation farming the concentration of TDS is built up by evapotranspiration losses. Therefore, the water supplied to an irrigated area must be sufficient to carry away the total quantity of salt in the irrigation water supply. This is possible only where good drainage exists or is provided. Otherwise, the salt build-up in the soil will eventually make the land unproductive. All consumptive uses of water contribute to the TDS concentration build-up.

In the first few years of a new irrigation development in properly drained soil, salt in excess of that applied will be leached from the soil. This will continue until an equilibrium has been established.

In areas without good internal drainage, it will be difficult to prevent a salt build-up. The quality characteristic of the water supply also may change if the rate of use is altered. This can occur in ground-water sources of supply where heavy continuous pumping is required and consumptive uses deplete the total ground-water storage.

The quality of return flow also may be affected adversely by chemicals applied to the soil. A change in chemical quality of water may result from seasonal effects or periods of heavy usage. During periods of ice cover or extreme low flows, the basin stream flow may be derived in an abnormal degree from ground waters with different quality characteristics than those of the surface waters. This occurs in many of the smaller streams of the high plains.

Water quality data (chemical) have been obtained from many sampling stations in the Missouri River Basin on a fairly continuous basis since 1951. These basic data and projected streamflow depletions were used in estimating the effects of the subbasin framework plans on total dissolved solids concentrations in future water supplies.

By the year 2020, the consumptive use attributed to all forms of agricultural activity will amount to 76 percent of streamflow depletions, municipal and industrial uses will account for 12 percent, and evaporation from regulatory reservoirs and ponds will amount to 12 percent. The total net streamflow depletions by all uses above the 1970 level are estimated at 4.3 million acre-feet by 1980 increasing to 15.7 million acre-feet by the year 2020.

By the year 2020, the average annual TDS concentrations in the Missouri River are expected to range between 540 mg/l at Williston, N. Dak., to approximately 800 mg/l at Omaha, Nebr. Inflow from tributaries below Omaha would significantly reduce the average annual TDS concentrations in the lower reaches of the main stem of the Missouri River.

Figure 53 shows the expected variation in average annual TDS at selected points in the basin.

All salts in solution change the physical and chemical nature of water and exert osmotic pressure. Some have physiological or toxic effects. It is generally agreed that the salt concentration of good palatable water should not exceed 500 mg/l, although higher concentrations may be suitable for some uses. Their suitability, however, will depend on the types of salts in solution. The presence of nitrates, sulfides, and other poisonous salts can render water dangerous for some uses although the total solids concentration is apparently within acceptable limits. Among the dissolved solids, the other principal constituents of concern are the chloride, sulfate, calcium, and magnesium salts. Other constituents, which are not usually found in undesirable quantities within the basin, but require surveillance, include fluorides, phosphates, iron, manganese, boron, and selenium.

In general, the TDS concentrations are high in the tributary streams of the high plains area of the western portions of North Dakota, South Dakota, Nebraska, and Kansas while other tributaries, especially those in Iowa and Missouri, have lower concentrations of TDS. The indications are that many of the basin's streams have TDS which now exceed the desirable 500 mg/l concentration set by most state water quality standards. These concentrations will increase with additional development.

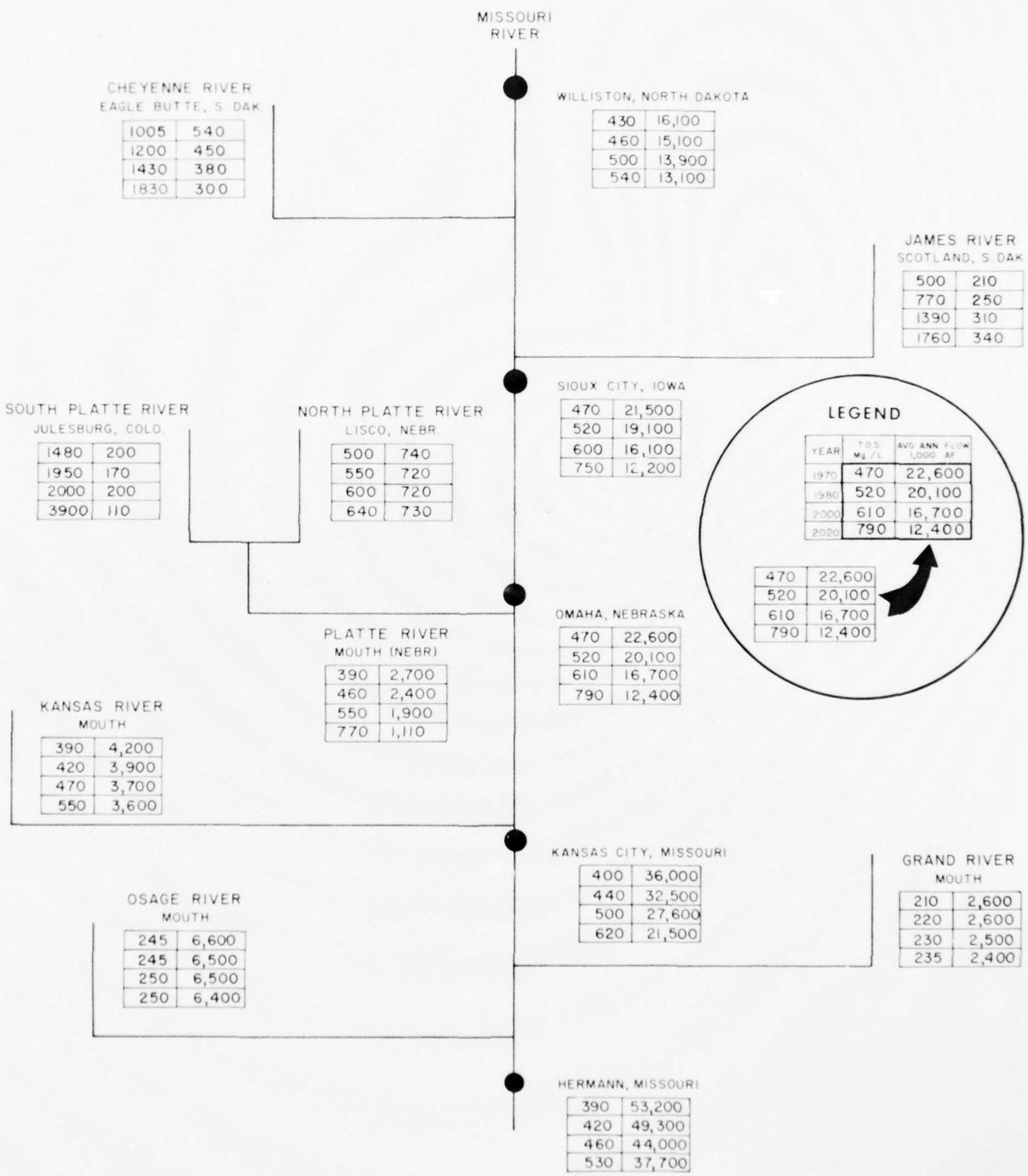
Added Water Yield Management

For the pertinent subbasins, the potential for increasing the natural surface water yield through forestry and precipitation management programs has been outlined. Based on extensive research and test studies already accomplished and continuing, table 113 presents the rates of yield increases that might be expected over the projection period from mountainous areas of the basin.

Aside from technical, legal, institutional, and related considerations for implementing these programs, a need for beneficial use of such increased water supply must be established. In the Upper Missouri and Yellowstone subbasins, all water demands can be met by the use of existing water supplies. The need, if any, for the added water in these two subbasins, therefore, would have to be downstream on the Missouri River. Assuming that the costs for producing the increased water yields are reasonable, the value of the added power production at the main stem reservoir system and other downstream uses would be greater than the costs. Therefore, these programs for the two subbasins should be retained

FIGURE 53

TOTAL DISSOLVED SOLIDS CONCENTRATIONS
AT KEY LOCATIONS IN THE MISSOURI BASIN
WITH FUTURE DEVELOPMENT



within the context of a framework plan pending further detailed studies on the practicability, dependability, costs, and the legal, institutional, and environmental considerations applicable to these programs.

Table 113 – ADDED WATER YIELD MANAGEMENT RESPONSE FROM SUBBASIN FRAMEWORK PLANS
MISSOURI BASIN

Subbasin	Feature	Projected Potential 1980	Projected Potential 2000	Projected Potential 2020	Plan Response 1980	Plan Response 2000	Plan Response 2020
		(Thousand Acre-Feet/Year Cumulative Above Current)					
Upper Missouri	Forest Management	70	70	70	13	42	70
	Precipitation Management	196	196	196	20	79	196
Yellowstone	Forest Management	145	145	145	45	136	145
	Precipitation Management	536	536	536	89	267	536
Western Dakota	Forest Management	8	8	8	0	8	8
Platte-Niobrara	Forest Management	213	213	213	59	213	213
	Precipitation Management	538	538	538	94	218	538
Missouri Basin	Forest Management	436	436	436	117	399	436
	Precipitation Management	1,270	1,270	1,270	203	564	1,270

Induced Snowfall May Provide Additional Water Supply In The Future

The same considerations outlined would also apply to the Platte-Niobrara Subbasin. However, in this subbasin additional water supplies, either by induced water yields or from other sources, are required to meet quantified future demands. In this subbasin, it is important that a detailed study of alternative potentials be explored so that decisions as to a future course of action can be determined within the near future.

RELATIONSHIP OF FRAMEWORK PLAN FEATURES TO PLANNING OBJECTIVES

In view of the reconnaissance scope of the framework study, an assessment as to the extent that developmental and managerial features of the subbasin frameworks meet the multiple planning objectives can be based in part on quantitative values, but must rely heavily on value judgments. In order to determine national efficiency gains, it would be necessary to express all demand or need functions in terms of price relationships from which net income could be determined. As was discussed in chapter 5, some functional demands, or needs, were expressed in monetary terms, whiles others were not. For the regional objective, similar situations are created since value judgments were made as to what would constitute a desirable regional economy. Here, more detailed evaluations of local or regional impacts are required. The environmental objective poses even greater problems since many environmental features reflect value judgments which may vary considerably depending on whose judgments are accepted. For all practical purposes, the individual subbasin framework plans reflect a mix of features that is generally responsive to all framework planning objectives, but more nearly maximizes the regional objectives. Therefore, some departures from the national efficiency and environmental objectives are inescapable. Studies were undertaken to further define the regional goals and to assess the impacts of these departures.

Agricultural Production

A number of plan features were scaled to meet the national or regional objectives. However, the agricultural outputs from these functions would provide production gains which may or may not be fully consonant with national efficiency gains. Therefore, a study was made to determine the extent to which these functions add or subtract from agricultural production, and comparisons were made to projected national requirements for food and fiber. Table 114 presents the results of this study. In order to achieve the production indicated by the framework plan, certain conditions are required. These are: (1) a reallocation of regional shares of national production; (2) increases in total national demand not foreseen in the projections; or (3) the maintenance of market clearing prices through retirement of marginal croplands and a transfer of activity to the developed resources. Without some mix of the conditions outlined, a price reaction could take place and preclude the developmental capability as indicated by the framework plan.

Table 114 — AGRICULTURAL PRODUCTION CAPABILITY FROM MISSOURI BASIN FRAMEWORK PLAN

Production Feature	Current Capability	1980	2000	2020
		(Million Bushels of Corn Equivalents)		
Research, Technology, Land Use Efficiency, Land Conservation, and Land Shifts	3,572[1]	1,203	1,078	1,132
Flood Control		36	45	69
Group Drainage		2	5	4
Erosion Control		5	25	26
Irrigation Development				
Private Ground Water		129	189	382
Private Surface Water		34	75	147
Public Project		37	78	97
System Improvements		22	32	54
Reserve Idle Remaining	248	41	-12	-277
Production Losses				
Fish and Wildlife		-11	-6	-6
Recreation		-8	-17	-22
Reservoir Construction		-28	-32	-21
Miscellaneous		-1	-1	0
TOTAL INCREMENTAL FRAMEWORK PLAN RESPONSE		1,461	1,459	1,585
TOTAL CUMULATIVE VALUES	3,820	5,281	6,740	8,325
REGIONAL SHARE OF NATIONAL REQUIREMENT	3,572	4,775	5,853	7,395
RATIO: RESPONSE TO REQUIREMENT	1.07	1.11	1.15	1.13

[1] All sources — nonirrigated and irrigated lands.

The functional features are all responsive to the regional objective and meet the national efficiency objective to varying degrees. As mentioned previously, the evaluation of national gains cannot be made at this time because projected national, regional, and interregional relationships of the future agricultural economy cannot be defined. Moreover, other social as well as economic objectives should be considered in determining courses of action relative to improvements which enhance agriculture. In parts of the Missouri Basin, implementation of the programs described may well be in the national interest as a means for promoting more uniform national growth and as a means for reducing the high social costs of low density populations. Further discussion of the impacts from full utilization of the region's agricultural production capability is contained later in this section.

Other Industrial

Framework plan features were formulated also to meet indicated needs for forestry, electric power, and mining and manufacturing. Plan features with respect to forest resources are limited to a conservation and management program to preserve the resource and to potentially increase water yields. With respect to forestry production, the existing resource capacity as well as that over the long term exceeds projected demands. Therefore, the processing of lumber products would be in response to market demands and the subbasin framework plans do not affect and are not affected by the production demands. The management program for increasing future forest water yields has certain ramifications. Any major increase in water yield will depend on a specific downstream need and beneficial use which would bear the cost for the additional water supply. As such, it would meet an economic need and result in economic gains. This type of program has been underway for some time and it is assumed that there would be no detrimental effects on the environment.

In the mining and manufacturing sector, plan features are aimed at providing for water supply needs as indicated by base line projections — with one notable exception. In the Yellowstone Subbasin, plan features are aimed also at supplying water for a large emerging coal-hydrogenation industry. This industry, as it materializes in the future, would provide both national and regional efficiency gains. The features of the subbasin framework plans would meet all projected industrial water needs, with flexibility to transfer water between uses at some future time — dependent of course on economic and social needs.

The electric power needs of the basin will be met in the future and will be in support of base line projections. For plan formulation purposes, it has been assumed that quality standards for streamflow temperature control will be met. In order to accomplish this goal, offstream cooling ponds and the use of cooling towers will be required. This can be accomplished only at additional cost and obviously at costs much higher than those required for flow-thru cooling power plants. This reflects a value judgment that the consumer will accept the costs in order to maintain certain environmental conditions.

Navigation

As was pointed out in chapter 7, the existing navigation function on the Missouri River would be seriously impaired sometime after the year 2000, assuming that subbasin plan features would all be implemented. Detailed studies that will be required some 20-30 years from now will have to consider all affects on the economy that may result and a proper course of action must then be determined.

The Environment

The quality of the basin's environment would be generally enhanced with full implementation of the framework plan features. Such enhancements would stem from higher levels of treatment of municipal and industrial wastes; management of agricultural wastes; low-flow augmentation; extensive land and water developments with significantly high values for fish, wildlife, and recreation purposes; stream preservation; supplemental thermal power cooling systems to maintain stream temperature control; cleaner water for domestic, industrial, and other uses; considerable control of floods; management of flood plain lands for minimizing future flood losses and for creating new opportunities for recreation activities and open spaces; and preservation of historical sites. All of these are responsive to the environmental plan objective. They also are responsive in varying degrees to the national and regional objectives. Obviously, some of the values, such as open space, are intangible and reflect judgments as to the public's willingness to pay for a better environment. These, then, are preference values that the people of the region and the Nation will have to set and accept. These should become clearer in the near future.

Although the overall quality of the basin's environment would be improved by the framework plan features, certain forms of water quality degradation will have to be accepted if the needs and desires of the basin's residents are to be met now and in the future. For most areas of the basin, treatment of organic wastes, coupled with low-flow augmentation where needed and feasible, should result in acceptable levels of stream quality. Emerging programs with respect to feedlot

wastes also should be equally effective. However, the picture with respect to inorganic wastes, dissolved solids, and natural "pollutants" such as silt is not as bright. As demonstrated by figure 53, total dissolved solid concentrations at many key points in the basin would exceed the desirable limit of 500 mg/l and, in some locations, exceed usable limits of 1,500 mg/l, with increased water use or streamflow depletions. The average TDS concentration in the South Platte River at the present time approaches 1,500 mg/l. Practically all of the water supply in the South Platte area is committed to use for industry, municipalities, irrigation, and other functions. In some parts of the basin, TDS concentrations exceed 500 mg/l at the present time, even though water use is very low. Such high concentrations, therefore, reflect natural sources of such pollution. A typical example is the Cheyenne River with an average TDS concentration near its mouth of over 1,000 mg/l. Without some kind of technological breakthrough, this form of degradation of water quality is inevitable and will have to be accepted.

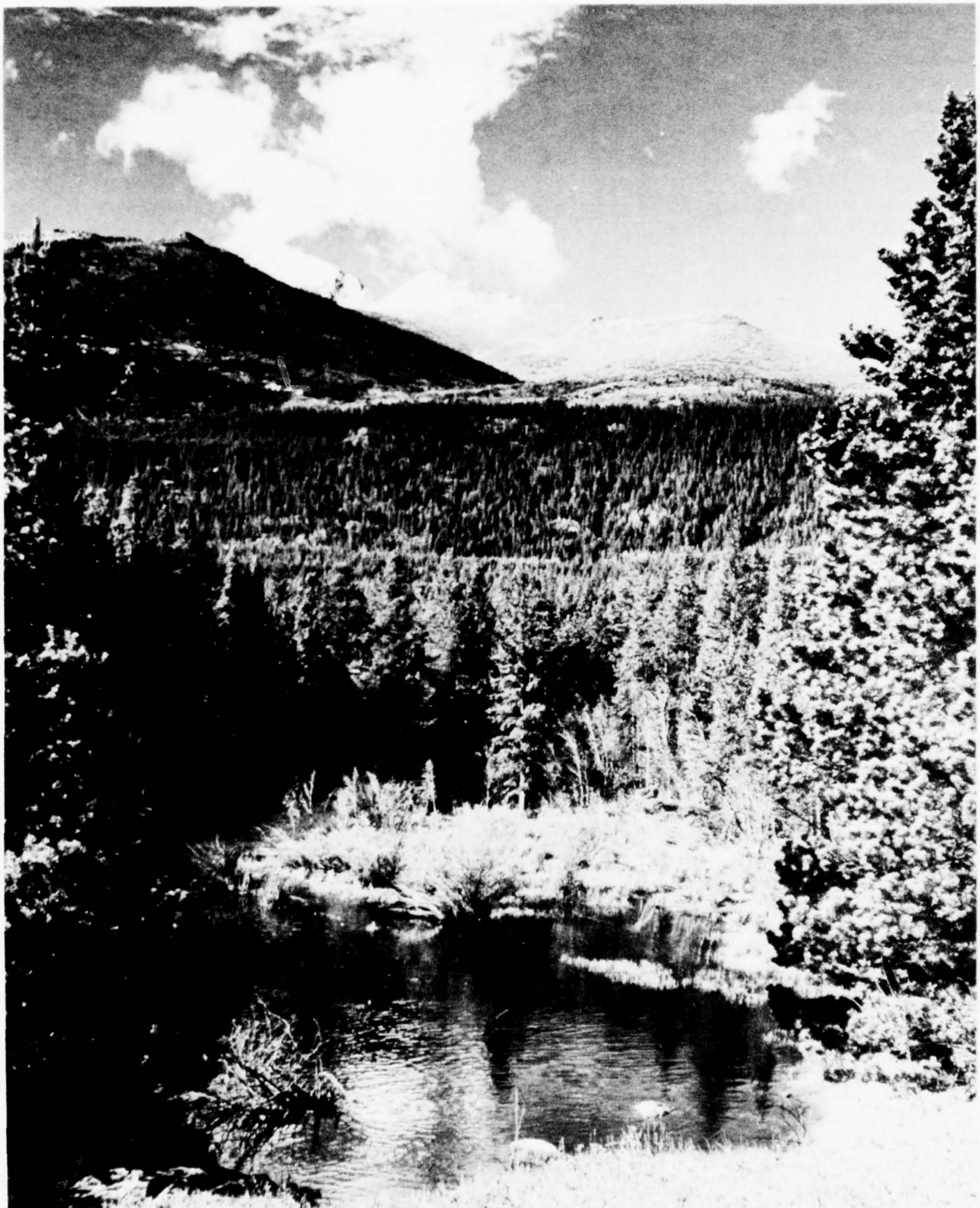
Stream degradation, especially as affecting fisheries, that stems from sedimentation would be somewhat minimized by land management programs and other erosion control measures. However, physical and cost constraints preclude substantial sediment reductions over large areas. Only in some localized areas is it economically or physically feasible to exercise significant control of sedimentation. The most critical area in the Missouri River Basin from this standpoint is the Middle Missouri Subbasin. In general, future conditions with the framework plan features implemented will not result in further stream degradation from high sediment loads. Neither can a highly enhanced condition be expected, although some localized areas would be enhanced substantially.

On balance, the total environmental quality of the basin in terms of water and land should be materially enhanced with the framework plan. Certain detrimental effects must be recognized as a consequence of consumptive beneficial uses of water, but the deterioration would not be such as to materially affect the well being of the residents of the basin.

Impacts

Regional economic impact as measured by population, employment, and income was analyzed for those developments that could create such impact beyond the base line projections. These include impacts from the agricultural capability supported by the frameworks, the coal-hydrogenation industry not included in original projections, and the impacts of the recreational capability. The appendix "Economic Analysis and Projections" presents a detailed discussion of the impact studies made and the pertinent values for each subbasin. With all of the features cited, employment for the basin should be about 170,000, 254,000, and 406,000 greater for the years 1980, 2000, and 2020 respectively, from the original projections. Since one of the major planning objectives was to intensify agriculture, the agricultural impacts become significant. With the total plan, projected farm population declines as indicated by the original projections would be dampened by 85,000, 87,000, and 48,000 by target years 1980, 2000, and 2020, respectively. Total population increases with the framework plan implemented would be 435,000 (1980), 650,000 (2000), and 1,039,000 (2020).

The framework plan features, therefore, are responsive to the regional objective. Subject to economic considerations previously noted, the implementation of the framework plan would appear to be generally in consonance with most planning objectives. It also reflects developments oriented toward a regional social and economic pattern that do not depart significantly from national and environmental objectives.



A Time For Meditation

CHAPTER 9

FRAMEWORK PLAN IMPLEMENTATION

The framework plan for the basin reflects a summation of the individual subbasin framework plans. Figures 54 and 55 show major features of the 1980 basin framework plan by geographic location. However, a number of factors will affect significantly the rate of implementation of the plan and its integral subbasin components. Framework plan features were formulated in response to indicated future needs, based on projected economic conditions for earlier target years and through the year 2020. After plan formulation was essentially complete, modified national and regional economic projections became available. These indicate significant departures from the original base-line projections. The framework plan features were formulated without consideration of such constraints as funds availability, planning and construction capabilities, and time required to process authorizing documents. Over the long term, the magnitude and confirmation of actual needs will govern, but implementation of the framework plan in the near term will be affected directly by the magnitude of these constraining factors.

ECONOMIC PROJECTIONS

As discussed in chapter 5, individual demand functions are sensitive to the economic parameters of population and income. The revised projections of basin population and income indicate lower populations, but higher income levels, when compared to the original projections underlying the study. This poses a complicated problem in appraising their probable input since demand projections usually reflect the influence of both parameters. However, reasonable appraisals of possible effects of adjustments in demand projections can probably be achieved if only the principal parameter affecting any individual functional demand is recognized. Table 115 presents the indicated changes in the economic projections of population and income.

With respect to the changes in economic projections, needs for water and related land resources development in the Missouri Basin at the 1980 level should not be significantly affected. However, the near-term physical and fiscal constraints would have a bearing on implementation of the 1980 framework plan features. Over the long-term, the effect of the new series of economic projections, if borne out, would probably reduce investment requirements by about 15-20 percent. In effect, the result would be one of extending the total demands and the investment period from 2020 to 2030 or beyond. These values reflect judgment approximations of the effect that the new economic projections would have on needs. A detailed analysis of the water resource needs based on these economic projections was not made since the indicated range of effect is considered well within the limits of accuracy of a framework study. However, the subbasin framework plans were analyzed to determine the adjustments that would be required when physical, time, and fiscal constraints for the 1980 level were imposed.

Table 115 – POPULATION AND TOTAL PERSONAL INCOME DIFFERENCES FROM ORIGINAL PROJECTIONS

	Population Difference in Percent			Personal Income Difference in Percent		
Subbasin	1980	2000	2020	1980	2000	2020
Upper Missouri	-11	-21	-32	+6	+5	+2
Yellowstone	-11	-25	-36	0	-4	-7
Western Dakota	-16	-24	-35	-2	-3	-9
Eastern Dakota	-7	-21	-34	+13	+11	+4
Platte-Niobrara	-13	-20	-29	+8	+13	+14
Middle Missouri	-5	-17	-28	+12	+14	+11
Kansas	-9	-16	-21	+6	+10	+16
Lower Missouri	-6	-11	-18	+14	+20	+24
Missouri Region	-8	-17	-26	+8	+11	+12

PLANNING AND TIME CONSTRAINTS

Implementation of developmental and managerial programs for water and related land resources will require preparation of planning reports, which must be approved by some decision-making body, the detailed design of the program features, and investments required to carry out these programs. This procedure would be followed regardless of the sector responsible for implementation – Federal, State, local governmental units, or private. Therefore, time to prepare and process approval


1
2
3
5
SHELBY
HAVRE
MILK RIVER
MALTA
GLASGOW
WILLISTON
VAUGHN
SUN RIVER
GREAT FALLS
ROY
WEST GLENDIVE
MEDORA
MILES CITY
MARMARTH
FORSYTH
SCRANTON
CLYDE PARK
BILLINGS
JOLIET
YELLOWSTONE
LOVELL
SHERIDAN
BELLE FOURCHE
CODY
GREYBULL
BUFFALO
RAPID CITY
WORLAND
THERMOPOLIS
HOT SPRINGS
DUBOIS
LANDER
CASPER
CHADRON
SCOTTSBLUFF
LARAMIE
CHEYENNE
FORT COLLINS
EVANS
LONGMONT
FORT MORGAN
BRUSH
AKRON
DENVER
ENGLEWOOD
GOLDEN
MORRISON
BURLINGTON
CHEYENNE WELLS
HOLYOKE
IMPORT 6,000 AF
IMPORT 105,000 AF
IMPORT 401,000 AF
COLORADO
WYOMING
SCALE 1:6,400,000
APPROXIMATE SCALE IN MILES
LOCATION MAP
MISSOURI RIVER BASIN
N

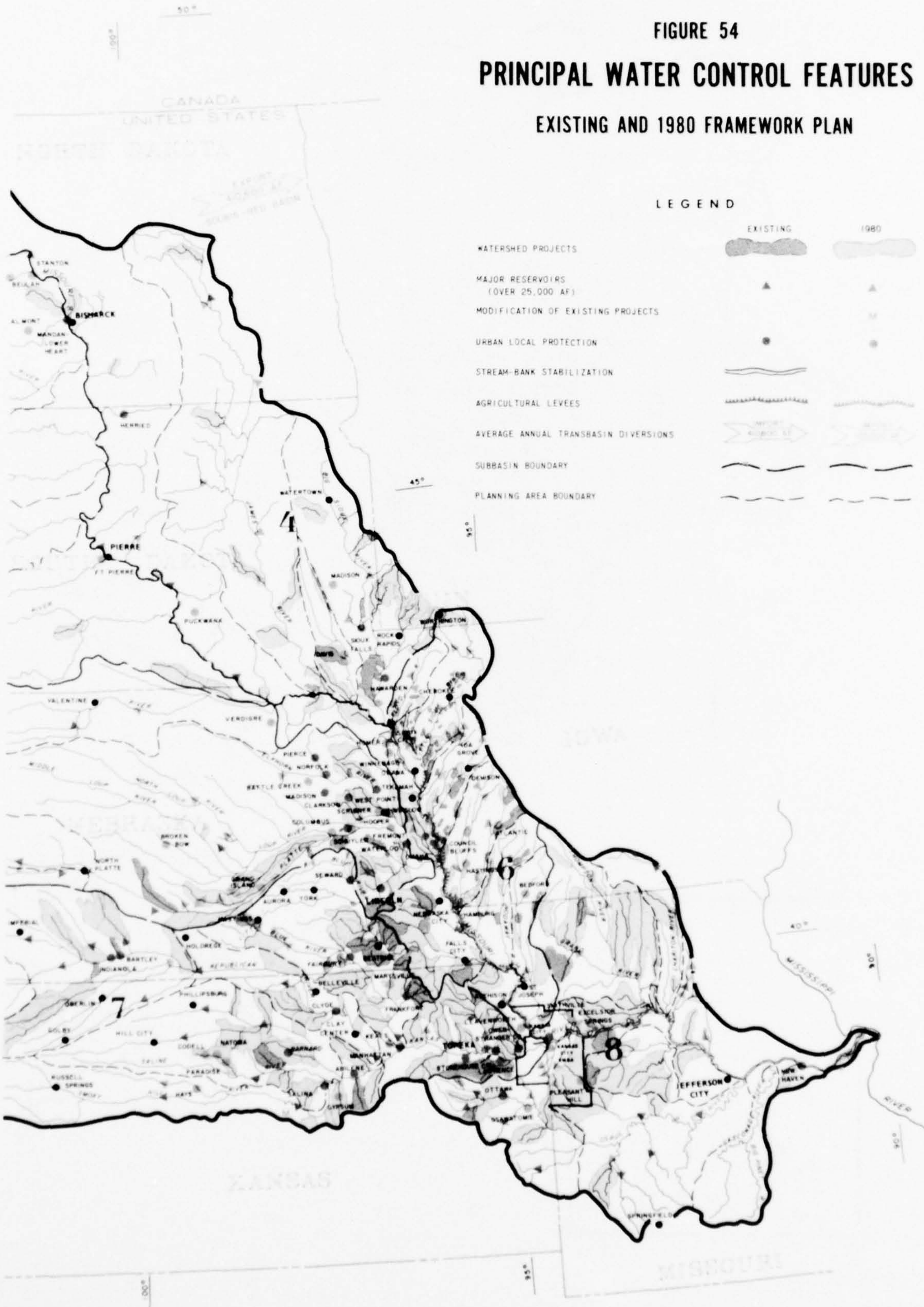
FIGURE 54

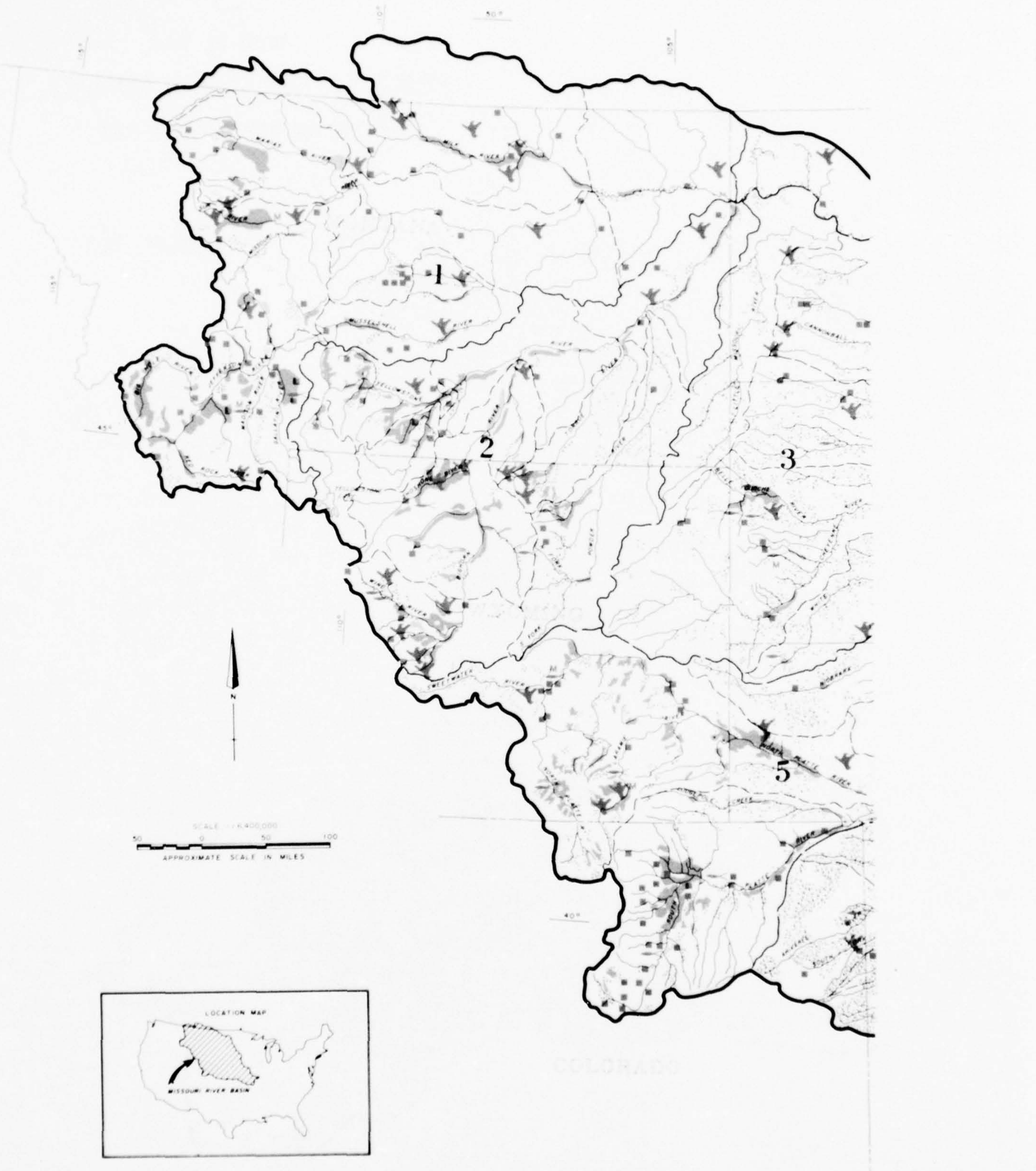
PRINCIPAL WATER CONTROL FEATURES

EXISTING AND 1980 FRAMEWORK PLAN

LEGEND

	EXISTING	1980
WATERSHED PROJECTS		
MAJOR RESERVOIRS (OVER 25,000 AF)	▲	▲
MODIFICATION OF EXISTING PROJECTS		M
URBAN LOCAL PROTECTION	●	●
STREAM-BANK STABILIZATION		
AGRICULTURAL LEVEES		
AVERAGE ANNUAL TRANSBASIN DIVERSIONS		
SUBBASIN BOUNDARY		
PLANNING AREA BOUNDARY		

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2
3
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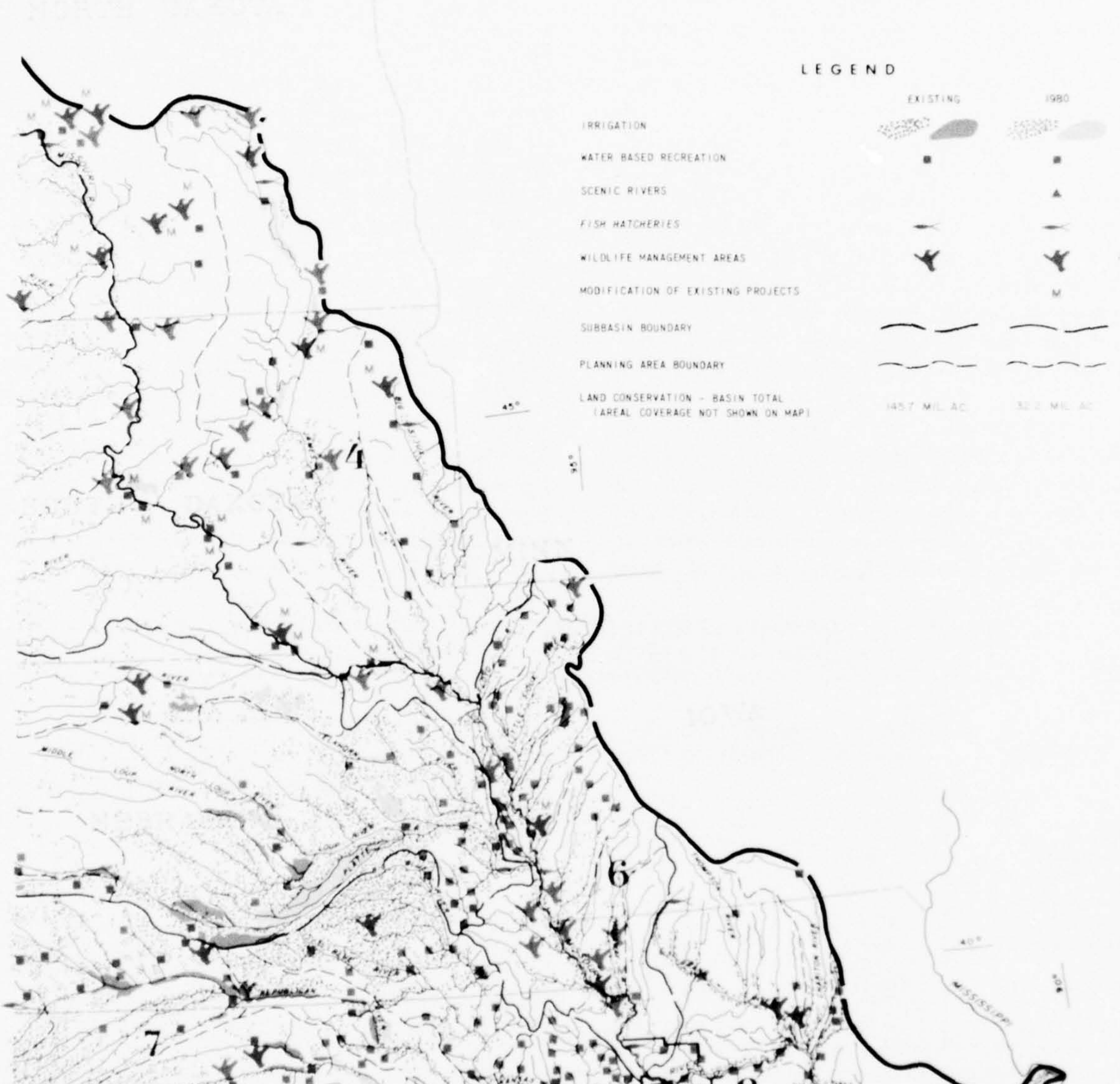
50 0 50 100
APPROXIMATE SCALE IN MILES
LOCATION MAP
MISSOURI RIVER BASIN

FIGURE 55

RELATED LAND DEVELOPMENT FEATURES

EXISTING AND 1980 FRAMEWORK PLAN



reports, which reflects a *planning capability* as well as review and approval time requirement, has a direct bearing on whether plan features included in the 1980 framework could be fully implemented by that time. Data and information on time and capability factors in the non-Federal governmental and private sectors are not sufficient to permit a meaningful analysis of the impacts of these constraints to be made at this time. In the Federal sector such information is available and these constraints can be analyzed with respect to federally financed water projects. Accordingly, analyses were made of the Federal water projects in light of time and planning capability constraints. The general extent and magnitude of the results of such analyses will give a general indication as to the effects these types of constraints may have in the non-Federal sectors. There is *no reason* to believe, however, that the non-Federal sectors have water resource planning capabilities greater than the Federal sector, and in all probability they are less.

Full implementation of the federally-financed plan features at the 1980 level would have an investment requirement of about $3 billion. Some of these improvements have been authorized for construction, some are proposed in preauthorization documents which are currently being processed, and many others will require preparation of preauthorization reports before they can be implemented. Since the bulk of the 1980 Federal water projects would require planning by the three principal planning and construction agencies — Bureau of Reclamation, Corps of Engineers, and Soil Conservation Service — a compilation was made of those agency projects together with investment requirements which were included in the 1980 framework and which are *authorized for construction*, or for which feasibility reports have been prepared and authorization is pending. For the remaining plan features, the number of feasibility reports required *during the 1970-80 time period*, together with investment requirements, were also determined. For this part of the analysis, the number of reports and the investment requirements of the plan features were distributed through the decade by one-third time increments. This reflects a priority setting, by time, as to the order that studies and developments should be initiated and completed and is based, generally, on studying areas in order of needs and problems. It does not reflect consideration of the agency capabilities to carry out the planning and development programs. Table 116 summarizes the items discussed and indicates the magnitude of the planning program required to implement the 1980 federally financed water control features in the framework plan.

Table 116 — *FEASIBILITY REPORTS COMPLETED OR REQUIRED TO IMPLEMENT FEDERAL WATER PROJECTS IN 1980 FRAMEWORK PLAN*

Subbasin	Projects Authorized	Feasibility Reports Completed – Projects Not Authorized	Feasibility Reports Required with Time Priorities, Numbers and Project Values in 1980 Framework					
			1970 — 1973		1974 — 1976		1977 — 1980	
			Number	Value	Number	Value	Number	Value
	(Project Values in Millions of Dollars)							
Upper Missouri	12.1	294.3[1]	3	1.0	5	9.9	6	2.9
Yellowstone	0	7.2	2	3.2	3	2.9	9	10.6
Western Dakota	1.8	0	12	28.0	7	2.9	7	12.0
Eastern Dakota	139.7	51.5	8	18.6	9	4.6	9	1.6
Platte-Niobrara	145.7	177.6	15	160.8	18	154.9	22	35.0
Middle Missouri	58.9	10.7	16	45.4	21	32.2	28	60.2
Kansas	70.6	6.1	16	91.0	20	43.7	38	54.5
Lower Missouri	498.4	120.8	7	15.5	15	37.2	32	54.5
Missouri Basin	927.2	668.2	79	363.5	98	288.3	151	231.3

[1]Includes one recently completed report for a project with a value of $183 million that is infeasible at this time.

Of the 328 individual preauthorization studies and reports required to implement Federal water projects by 1980, 252 reports reflect the preparation of work plans by the Soil Conservation Service under the provisions of Public Law 566. The *remaining* 76 studies would be made by the Bureau of Reclamation and the Corps of Engineers. Of the latter, and from a reporting standpoint, only 63 preauthorization reports would be required since many individual plan features fall within river basins which would be studied in total by the action Federal agencies. Also, of the indicated 63 reports in this category, 36 would reflect studies of local flood problems at urban areas which would not require major river basin investigations. Accordingly, the total study program for the decade of the 70's required to implement Federal water projects in the 1980 level framework plan would include 251 watershed studies, 27 studies of parts or all of river drainages, and 36 studies of local urban flood problem areas. All of these studies would be subject to varying degrees of coordination between Federal agencies, the affected States, and local interests.

From a timing standpoint alone, those investigations and projects or programs indicated for completion during the 1977-1980 period probably could not be

coordinated, authorized, and funded for completion of construction by 1980. This constraint would reduce the 1980 framework investment requirement by $231.3 million. As indicated in table 116, one recently completed investigation demonstrates infeasibility of a $183 million investment by 1980. Therefore, the total investment constraint attributed to all factors cited would, therefore, approximate $414.3 million. The above-described analysis has been limited to water projects undertaken by the specified three Federal agencies. For the other federally financed plan features included in the subbasin framework plans, physical constraints are considered relatively insignificant. Those features, such as wildlife refuges, wetlands, flood plain information reports, and others would be subject principally to fiscal constraints in their implementation. Table 117 summarizes the magnitude of physical constraints to the Federal water projects study program for the 1970-1980 period.

FISCAL CONSTRAINTS

Total framework plan implementation would require investments to be made by the Federal, State, local, and private sectors. Table 118 presents a summary of the framework plan investments and the cost-sharing requirements of the Federal Government and non-Federal interests.

Table 117 – SPECIFIED FEDERAL AGENCIES STUDY PROGRAM AND INVESTMENTS AS RELATED TO 1980 FRAMEWORK PLAN AND AS CONSTRAINED BY PHYSICAL FACTORS

Subbasin	Unconstrained Program		Constrained Reports and Investments	
	Reports	Value of Improvements	Reports	Value of Improvements
	(Number)	($ Million)	(Number)	($ Million)
Upper Missouri	14	196.8[1]	7[1]	185.9[1]
Yellowstone	14	16.7	9	10.6
Western Dakota	26	42.9	7	12.0
Eastern Dakota	26	24.8	9	1.6
Platte-Niobrara	55	350.7	22	35.0
Middle Missouri	65	137.8	28	60.2
Kansas	74	189.2	38	54.5
Lower Missouri	54	107.2	32	54.5
Missouri Basin	328	1,066.1[1]	152[1]	414.3[1]

[1] Includes one recently completed report for a project with a value of $183 million that is not feasible at this time.

Table 118 – COST SUMMARY – FRAMEWORK PLAN, MISSOURI BASIN

Category	First Costs by Time Frame[1]			
	1980	2000	2020	Total
	(Billions of Dollars)			
FEDERALLY FINANCED FEATURES				
Federal Investment	3.0	3.3	5.0	11.3
Non-Federal Investment	0.1	0.1	0.1	0.3
Repayable Investment	1.3	1.8	1.2	4.3
Net Federal Investment	1.7	1.5	3.8	7.0
NON-FEDERAL FEATURES				
Non-Federal Investment	2.2	2.9	3.2	8.3
Federal Investment (Grants, etc.)	1.2	1.6	1.8	4.6
Total Investment	3.4	4.5	5.0	12.9
SUMMARY				
Initial Federal Investment	4.2	4.9	6.8	15.9
Initial Non-Federal Investment	2.3	3.0	3.3	8.6
Total	6.5	7.9	10.1	24.5
Percent Federal Investment	65	62	67	65
Percent Non-Federal Investment	35	38	33	35
Net Federal Investment	2.9	3.1	5.6	11.6
Total Non-Federal Investment	3.6	4.8	4.5	12.9
Total	6.5	7.9	10.1	24.5
Percent Federal Investment	45	39	55	47
Percent Non-Federal Investment	55	61	45	53

[1] All Values rounded.

As can be noted from table 118, initial Federal cumulative investments required for the federally financed features of the framework plan approximate $3 billion, $6.3 billion, and $11.3 billion for the 1980, 2000, and 2020 target years, respectively. These investments reflect funds in addition to those needed to complete Federal projects currently underway. As of 1970, an estimated $618.6 million is required to complete, by 1980, Federal water projects underway. During the 10-year period ending in 1969, Federal appropriations to the Corps of Engineers, Bureau of Reclamation, and Soil Conservation Service for water resource development in the Missouri Basin have averaged about $190 million annually, or a total 10-year fund total of $1.9 billion. Without regard for costs to complete projects underway and with no constraints imposed, this rate would have to be increased by approximately 58 percent to meet total new fiscal requirements for the 10-year period ending in 1980; or about 10 percent for the 30-year period through 2000; or 19 percent through the 50-year period ending in 2020. It is not unreasonable to assume that future appropriation rates will increase. However, projections of probable magnitude of investment rates that may prevail in the long-term future cannot be made with any degree of reliability. There is no apparent reason for such projections since programming of framework plan features beyond 1980 would not be useful or meaningful. However, in terms of time and planning capabilities and the indicated significant increases in Federal appropriations required to implement framework plan features, a fiscal constraint on the near-term framework plan features (1980) is inescapable.

Within the 1980 framework plan investment requirements, about $19.6 million has been expended for Federal projects started and essentially completed within the 1965-1969 time period. The estimated total investment requirements, for the 1970-1980 period, therefore, reflect the total framework plan investments required at the 1980 level, less investments made during the 1965-1969 period, plus the investments required to complete projects underway. From this total, the investments constrained by time and planning capability factors must be subtracted to arrive at the net investment requirements. Table 119 summarizes, by subbasins, total Federal investment requirements and the effects of timing and planning capability constraints.

Table 119 – ANALYSIS OF FEDERAL WATER PROJECT INVESTMENT REQUIREMENTS FOR IMPLEMENTATION OF 1980 FRAMEWORK PLAN

	INVESTMENT REQUIREMENTS						
Subbasin	1980 Framework	Completed Projects (1965-1969)	Required (1970-1980)	To Complete Projects Under Construction	Total Investment Requirement	Physical Investment Constraint	Net Investment Requirement
				($ Million)			
Upper Missouri	382.4	0	382.4	28.3	410.7	185.9	224.8
Yellowstone	116.5	0	116.5	25.5	142.0	10.6	131.4
Western Dakota	144.7	4.8	139.9	3.0	142.9	12.0	130.9
Eastern Dakota	293.3	0	293.3	50.6[1]	343.9	1.6	342.3
Platte-Niobrara	941.6	5.7	935.9	70.6	1,006.5	35.0	971.5
Middle Missouri	220.9	0.2	220.7	13.4	234.1	60.2	173.9
Kansas	283.0	8.9	274.1	99.6	373.7	54.5	319.2
Lower Missouri	790.3	0	790.3	250.9	1,041.2	54.5	986.7
Main Stem, Missouri River	0	0	0	76.7	76.7	0	76.7
Missouri Basin	3,172.7	19.6	3,153.1	618.6	3,771.7	414.3	3,357.4

[1] Includes $47 million for Garrison Diversion Unit assigned to Missouri Basin; an additional $163.6 million assigned to Souris-Red Basin will be required for this unit.

In order to illustrate an alternative investment program to that indicated by the subbasin framework plans at the 1980 level, a Federal budgetary constraint reflecting a modest increase in the annual historical basin average of $190 million was adopted. For this study, it is assumed that the historical average of Federal appropriations would increase at a rate equal to the projected increase in Gross National Product during the 1970-80 decade. In constant dollars this rate of increase is 4.2 percent and would give a mean equivalent value of about $240 million annually for the basin, or $2.4 billion during the decade. This is considered to be a reasonable average value in light of the near-term fiscal outlook. Although the framework plan features can be segregated into categories reflecting developmental features that require initial Federal investments, as well as non-Federal developments planned and implemented by the State, local, and private sectors, data on historic investments made by the latter are fragmentary and incomplete. Therefore, it is impracticable at this time to project future investment capabilities for the non-Federal programs under these conditions and for programming purposes, investment constraints were adopted for federally financed plan features only and exclusive of Federal grants and assistance.

A determination of the timing of the individual federally financed subbasin plan features at the 1980 level was made since significant variations do exist between subbasins. The evaluation was approached in two steps: (1) establishing an allocation to each subbasin of a constrained basin fund total, and (2) reprogramming the plan features within the allocated share of this basin total. There were a number of ways in which fund allocations to each subbasin could be made. They could be allocated on the basis of a ratio of subbasin population; income could be used as a parameter, or some ratio combining population and income could be developed.

Since plan features reflect to a great extent expenditures to meet needs (which also reflect a relationship to population and income), the allocation of the projected basin funds was made by deriving ratios of subbasin investments to the total basin investment. Use of totally unconstrained fund investment requirements was considered inadvisable in light of the physical constraints previously enumerated and distortions that would ensue. Accordingly, the net investment requirements shown in table 119 provided a basis for subbasin allocations of the basin investment total.

Funds available for this purpose for the 1970-1980 decade were considered to be the $2.4 billion already discussed less investments of $76.7 million required to complete Missouri River main stem projects now underway and otherwise not considered in earlier discussions. On this basis, table 120 presents the allocation of total anticipated investments to the subbasins for completion of projects now under construction ($618.6 million) and for projects to be implemented during that decade ($1,781.4 million).

Table 120 – ANALYSIS OF FEDERAL WATER PROJECT INVESTMENTS WITH FISCAL CONSTRAINTS FOR 1970-1980, 1980 FRAMEWORK PLAN

Subbasin	Allocation of Basin Investment		Investment to Complete Projects Under Construction	Net Fiscally Constrained Subbasin Allocations
	(Percent)	($ Million)	($ Million)	($ Million)
Upper Missouri	6.8	158.0	28.3	129.7
Yellowstone	4.0	93.0	25.5	67.5
Western Dakota	4.0	93.0	3.0	90.0
Eastern Dakota	10.4	242.0	50.6	191.4
Platte-Niobrara	29.6	688.0	70.6	617.4
Middle Missouri	5.4	125.3	13.4	111.9
Kansas	9.8	228.0	99.6	128.4
Lower Missouri	30.0	696.0	250.9	445.1
Main Stem, Missouri River		76.7	76.7	0
Missouri Basin	100	2,400.0	618.6	1,781.4

PROGRAMMING PLAN FEATURES

It should be recognized that any alternative funding level, Federal or non-Federal, could be assumed for programming purposes. The level assumed herein for Federal water projects is considered reasonable and does establish a base from which future adjustments can be made as the framework plan is updated. Moreover, investment adjustments between individual subbasins, as well as adjustments for individual projects within a subbasin (trade-offs), can be made as conditions dictate in the future.

Programming of the federally financed plan features for implementation by 1980, in response to physical as well as fiscal constrainsts, is presented in subsequent paragraphs. Sufficient data are not currently available to permit a similar program analysis to be made for those features requiring implementation by the non-Federal sector. However, as shown by table 118, Federal grants and assistance to the non-Federal sector, estimated to approximate $1.2 billion, were included in the total estimated cost for the non-Federal program. These grants and assistance programs normally involve matching funds from the non-Federal sector. The major decision to implement such improvements lies with various local subdivisions of government, and these improvements could be implemented with or without Federal funding. It is impractical at this time to fully assess the course the non-Federal sector will take, or the effects of any constraints that may be imposed in Federal grant programs. Because of the matching provisions of most grant programs, it would appear that total funds for implementing improvements in the non-Federal sector would fall short of the 1970-1980 requirement. In any event, as the plan is updated in the future, programming of the non-Federal investments should be made and implementation priorities determined.

UPPER MISSOURI SUBBASIN

In the Upper Missouri Subbasin, physical constraints reduce investment requirements significantly. These constraints reduce the 1980 multiple-purpose storage

impoundments from about 1.8 million acre-feet to just under 300,000 acre-feet and a slight reduction in the channel and levee improvement for local flood protection. By 1980, there would be considerable water surplus in the subbasin and no apparent need to assume the investments necessary for increased water yields from forest and precipitation management programs. Moreover, it appears that the budgetary allocation to this subbasin may be somewhat high in relation to other subbasins having much greater populations. This facet can be analyzed in the future as the framework plan is updated. Table 121 presents the results of the program analysis and shows the differences between the constrained and unconstrained subbasin framework plan at the 1980 level.

Table 121 – PROGRAMMED FRAMEWORK PLAN FOR 1980, UPPER MISSOURI SUBBASIN

Plan Features	Unit	Physical Measure		First Cost ($1,000)	
		Unconstrained	Constrained	Unconstrained	Constrained
Federal Financed Features					
Irrigation Rehabilitation				12,800	6,400
Wildlife Refuge Addition	Number	1	1	1,100	1,100
Fish Hatchery	Number	1	1	100	100
Single-Purpose Flood Control	Miles	17	15	5,900	5,500
Bank Stabilization	Miles	36	36	700	700
Multiple-Purpose Reservoirs	1,000 AF	1,799	299	223,000	37,500
Federal Irrigation	1,000 AC	192	108	133,200	75,300
Federal Land Conservation	1,000 AC	773	773	1,800	1,800
Wildlife Wetlands	1,000 AC	10	10	900	900
National Trails	Miles	815	815	300	300
Flood Plain Management	Reports	6	6	100	100
Forest Management	1,000 AF	13	0	100	0
Precipitation Management	1,000 AF	20	0	400	0
Non-Federal Costs (Initial)				2,000	1,800
Subtotal				382,400	131,500
Non-Federal Plan Features					
Recreation	1,000 AC	246		145,800	
Land Conservation	1,000 AC	4,587		84,000	
Recreation Reservoirs	1,000 AF	20		3,000	
Sewage Treatment	Plants	100		17,000	
Water Supply & Treatment				17,800	
Fish & Wildlife Management	1,000 AC	5		700	
Flood Plain Management	1,000 AC	2		1,100	
Subtotal				269,400	
Subbasin Framework Total				651,800	

YELLOWSTONE SUBBASIN

In this subbasin, multiple-purpose storage was constrained to the level indicated by physical limitations with relatively significant investment deferrals for irrigation rehabilitation, new irrigation development, and local flood protection works to meet fiscal constraints. Table 122 presents the results of the program analysis and as can be noted, the investment requirements for non-Federal plan features are significantly larger than for Federal water projects. It is in that sector, therefore, that significant investments must be made if a substantial portion of the needs of the area is to be met.

WESTERN DAKOTA SUBBASIN

The investment requirements for Federal as well as non-Federal plan features are roughly equivalent for this subbasin. In order to meet the fiscally constrained budget for Federal water projects, a reduction of about 30 percent in reservoir storage is considered a logical course, and includes recognition of physical constraints. Modest deferrals of other water developments also are required to meet the budgetary constraint. These are summarized in table 123 which shows the constrained and unconstrained plan features.

EASTERN DAKOTA SUBBASIN

Table 124, which presents the programmed 1980 framework plan, indicates a situation similar to that in the adjoining Western Dakota Subbasin. Physical constraints to developing reservoir storage, together with deferrals of other related plan features in response to fiscal constraints result in an overall investment reduction of about 32 percent. The constrained 1980 framework for this subbasin is considered possible of attainment and significant investments to complete projects started by 1980 will be required after that time.

Table 122 – PROGRAMMED FRAMEWORK PLAN FOR 1980
YELLOWSTONE SUBBASIN

Plan Features	Unit	Physical Measure		First Cost ($1,000)	
		Unconstrained	Constrained	Unconstrained	Constrained
Federally Financed Features					
Irrigation Rehabilitation				11,600	3,000
Single-Purpose Flood Control	Miles	14	7	4,000	2,000
Grade Stabilization	Number	14	7	200	100
Bank Stabilization	Miles	28	10	600	200
Multiple-Purpose Reservoirs	1,000 AF	286	236	60,000	49,400
Federal Irrigation	1,000 AC	41	13	31,100	10,060
Federal Land Conservation	1,000 AC	778	600	3,900	2,000
Fish Hatcheries	Number	2	1	700	300
National Trails	Miles	450	450	400	400
Flood Plain Management	Reports	5	2	100	40
Forest Management	1,000 AF	45	0	200	0
Precipitation Management	1,000 AF	89	0	1,800	0
Non-Federal Costs (Initial)				1,900	1,200
Subtotal				116,500	68,700
Non-Federal Plan Features					
Non-Federal Irrigation	1,000 AC	149		108,000	
Recreation	1,000 AC	131		88,500	
Land Conservation	1,000 AC	3,232		63,000	
Reservoir Modifications	1,000 AF	206		35,900	
Sewage Treatment	Plants	65		12,000	
Water Supply & Treatment				14,000	
Fish & Wildlife Management	1,000 AC	11		3,200	
Flood Plain Management	1,000 AC	11		7,100	
Subtotal				331,700	
Subbasin Framework Total				448,200	

Table 123 – PROGRAMMED FRAMEWORK PLAN FOR 1980
WESTERN DAKOTA SUBBASIN

Plan Features	Unit	Physical Measure		First Cost ($1,000)	
		Unconstrained	Constrained	Unconstrained	Constrained
Federally Financed Features					
National Recreation Area	1,000 AC	19	10	8,900	4,700
Irrigation Rehabilitation				5,900	2,000
Wildlife Refuge Addition	Number	1	1	2,000	2,000
Fish Hatchery & Impoundments	Number	5	2	1,000	400
Single-Purpose Flood Control	Miles	12	10	1,800	1,400
Grade Stabilization	Structures	23	12	300	150
Bank Stabilization	Miles	33	10	600	200
Multiple-Purpose Reservoirs	1,000 AF	793	525	105,000	69,850
Federal Irrigation	1,000 AC	29	15	3,700	1,800
Group Drainage	1,000 AC	8	8	500	500
Federal Land Conservation	1,000 AC	108	71	2,900	1,900
National Trails	Miles	195	98	10,100	5,000
Flood Plain Management	Reports	4	4	100	100
Non-Federal Costs (Initial)				1,900	1,700
Subtotal				144,700	91,700
Non-Federal Plan Features					
Non-Federal Irrigation	1,000 AC	127		25,400	
Recreation	1,000 AC	114		23,900	
Land Conservation	1,000 AC	4,050		91,000	
Fish & Wildlife Reservoirs	1,000 AF	2		200	
Sewage Treatment	Plants	110		18,000	
Water Supply Treatment				21,000	
Fish & Wildlife Management	1,000 AC	5		400	
Flood Plain Management	1,000 AC	2		200	
Subtotal				180,100	
Subbasin Framework Total				324,800	

Table 124 – PROGRAMMED FRAMEWORK PLAN FOR 1980
EASTERN DAKOTA SUBBASIN

Plan Features	Unit	Physical Meausre		First Cost ($1,000)	
		Unconstrained	Constrained	Unconstrained	Constrained
Federally Financed Features					
National Recreation Area	1,000 AC	18	10	8,100	4,700
Wildlife Refuge Additions	Number	7	5	4,300	3,000
Single-Purpose Flood Control	Miles	524	260	35,600	18,170
Grade Stabilization	Number	427	200	3,700	1,730
Bank Stabilization	Miles	3	3	100	100
Multiple-Purpose Reservoirs and Associated Joint Works	1,000 AF	1,625	1,160	147,000	104,890
Federal Irrigation	1,000 AC	73	30	5,700	2,360
Group Drainage	1,000 AC	6	6	700	700
Federal Land Conservation	1,000 AC	2	2	100	100
Wetlands	1,000 AC	1,124	1,000	52,800	42,500
Fish Impoundments	Number	36	15	9,200	7,860
National Trails	Miles	390	200	10,100	5,200
Flood Plain Management	Reports	9	4	200	90
Non-Federal Costs (Initial)				15,700	5,500
Subtotal				293,300	196,900
Non-Federal Plan Features					
Non-Federal Irrigation	1,000 AC	156		32,600	
Recreation	1,000 AC	168		2,900	
Land Conservation	1,000 AC	3,543		115,000	
Fish & Wildlife Reservoirs	1,000 AF	22		1,300	
Sewage Treatment	Plants	275		42,000	
Water Supply & Treatment				47,000	
Fish & Wildlife Management	1,000 AC	23		5,800	
Flood Plain Management	1,000 AC	51		9,200	
Subtotal				255,800	
Subbasin Framework Total				549,100	

This is attributed to the large authorized Oahe Irrigation Unit and other projects related thereto.

PLATTE–NIOBRARA SUBBASIN

Both physical and fiscal constraints affect the many plan features in this subbasin. Multiple-purpose reservoirs and local flood protection projects were constrained to levels indicated by physical considerations while most other plan features were constrained in light of fiscal limitations. It is pertinent to note here that Federal water project investments exceed those required to implement non-Federal plan features. Table 125 presents the constrained and unconstrained 1980 subbasin framework plan.

MIDDLE MISSOURI SUBBASIN

Federal investment requirements would be reduced by about 45 percent to meet the constrained fiscal allocation to this subbasin. Plan deferrals would be principally in storage reservoirs, local flood protection works, and grade stabilization works. Flood control and land stabilization needs in this subbasin are large and in relation to other subbasins they should have a relatively high priority for being met. Table 126 presents the magnitude of project deferrals required to meet physical and fiscal constraints and the constrained plan is reasonably attainable by 1980. However, as the framework plan is updated in the future, further analysis of subbasin budgetary allocations should be made with a view toward increasing funds to be allocated to the Middle Missouri Subbasin. It appears, on a judgment basis, that the allocation to the Upper Missouri Subbasin may be high compared to the Middle Missouri. The probability of trade-offs between these subbasins is highly likely in the future.

KANSAS SUBBASIN

Fiscal and physical constraints have a significant impact on 1980 framework plan implementation in this subbasin. The indicated fiscal constraint reduces the unconstrained investment requirement by about 55 percent. Significant deferrals for most plan features are required in order to meet a budgetary allocation of about $130 million during the decade of the 70's. However, this situation prevails because of the magnitude of funds required to complete projects currently under construction, a value of almost $100 million. Taken together, the "total" program during the 1970-1980 period is a large one. Table 127 shows the programmed framework plan at the 1980 level for the Kansas Subbasin.

Table 125 – PROGRAMMED FRAMEWORK PLAN FOR 1980
PLATTE-NIOBRARA SUBBASIN

Plan Features	Unit	Physical Measure		First Cost ($1,000)	
		Unconstrained	Constrained	Unconstrained	Constrained
Federally Financed Features					
Federal Land Recreation	1,000 AC	32	22	63,300	42,800
Wildlife Refuge Additions	Number	2	2	2,300	2,300
Irrigation Rehabilitation				32,200	16,000
National Trails	Miles	350	350	200	200
Fish Hatcheries & Impoundments	Number	30	30	5,300	5,300
Local Flood Protection	Miles	784	649	26,200	21,700
Single-Purpose Flood Control Reservoirs	1,000 AF	290	160	50,600	27,900
Hydro-Power Facilities				147,200	41,400
Grade Stabilization	Structures	72	72	500	500
Bank Stabilization	*Miles*	27	27	700	700
Multiple-Purpose Reservoirs	1,000 AF	3,735	3,400	398,000	367,500
Federal Irrigation	1,000 AC	176	83	177,300	83,600
Group Drainage	1,000 AC	160	34	3,200	700
Federal Land Conservation	1,000 AC	387	387	4,000	4,000
Flood Plain Management	Reports	34	34	800	800
Forest Management	1,000 AF	59	59	200	200
Precipitation Management	1,000 AF	94	94	1,800	1,800
Non-Federal Costs (Initial)				27,800	23,100
Subtotal				941,600	640,500
Non-Federal Plan Features					
Non-Federal Irrigation	1,000 AC	593		133,600	
Recreation	1,000 AC	48		106,200	
Land Conservation	1,000 AC	6,188		232,000	
Reservoir Modifications	1,000 AF	3		600	
Sewage Treatment	Plants	350		71,000	
Water Supply & Treatment				114,900	
Fish & Wildlife Management	1,000 AC	48		22,300	
Flood Plain Management	1,000 AC	79		51,100	
Subtotal				731,700	
Subbasin Framework Total				1,673,300	

Table 126 – PROGRAMMED FRAMEWORK PLAN FOR 1980
MIDDLE MISSOURI SUBBASIN

Plan Features	Unit	Physical Measure		First Cost ($1,000)	
		Unconstrained	Constrained	Unconstrained	Constrained
Federally Financed Features					
Wildlife Refuge Additions	Number	3	2	2,400	1,600
Single-Purpose Flood Control	Miles	146	73	10,800	5,400
Grade Stabilization	Structures	1,706	840	24,900	12,300
Bank Stabilization	Miles	325	100	4,500	1,400
Multiple-Purpose Reservoirs	*1,000 AF*	2,293	1,250	165,500	90,200
Group Drainage	1,000 AC	29	29	100	100
Fish Hatcheries	Number	2	2	700	700
Flood Plain Management	Reports	22	11	400	200
Non-Federal Costs (Initial)				11,600	6,200
Subtotal				220,900	118,100
Non-Federal Plan Features					
Non-Federal Irrigation	1,000 AC	239		47,800	
Recreation	*1,000 AC*	89		40,800	
Land Conservation	1,000 AC	1,491		77,000	
Recreation Reservoirs	1,000 AF	373		42,100	
Sewage Treatment	Plants	300		50,000	
Water Supply & Treatment				74,600	
Fish & Wildlife Management	1,000 AC	59		17,600	
Flood Plain Management	1,000 AC	93		18,000	
Subtotal				367,900	
Subbasin Framework Total				588,800	

Table 127 – PROGRAMMED FRAMEWORK PLAN FOR 1980, KANSAS SUBBASIN

Plan Features	Unit	Physical Measure		First Cost ($1,000)	
		Unconstrained	Constrained	Unconstrained	Constrained
Federally Financed Projects					
Wildlife Refuge Additions	Number	2	1	900	500
Reservoir Modification	1,000 AF	162	162	3,300	3,300
Single-Purpose Flood Control	Miles	79	29	8,300	3,100
Grade Stabilization	Structures	218	93	7,000	3,000
Bank Stabilization	Miles	71	30	1,700	700
Multiple-Purpose Reservoir	1,000 AF	2,304	1,100	211,000	100,000
Federal Irrigation	1,000 AC	67	26	41,100	16,000
Group Drainage	1,000 AC	9	1	400	100
Federal Land Conservation	1,000 AC	18	18	100	100
Fish and Wildlife Wetlands	1,000 AC	12	4	2,900	900
Hatcheries & Impoundments	Number	2	2	300	300
National Trails	Miles	275	165	500	300
Flood Plain Management	Reports	9	4	200	100
Non-Federal Costs (Initial)				5,300	3,000
Subtotal				283,000	131,400
Non-Federal Plan Features					
Non-Federal Irrigation	1,000 AC	663		132,600	
Recreation	1,000 AC	91		103,800	
Land Conservation	1,000 AC	5,035		182,000	
Sewage Treatment	Plants	350		52,000	
Water Supply & Treatment				106,600	
Fish & Wildlife Management	1,000 AC	13		1,400	
Flood Plain Management	1,000 AC	50		21,800	
Subtotal				600,200	
Subbasin Framework Total				883,200	

LOWER MISSOURI SUBBASIN

A situation similar to the Kansas Subbasin is found in the Lower Missouri, and more so. The constrained fiscal budget of $475 million when coupled with fund requirements to complete projects underway, $250 million, reflects a large subbasin investment during the 1970-1980 period. The principal deferrals to meet constraints would be about a 35 percent deferral in investments for reservoir storage and other modest deferrals for local flood protection, grade stabilization structures, and drainage. Table 128 presents the magnitude of the constrained 1980 framework plan in this subbasin.

Table 128 – PROGRAMMED FRAMEWORK PLAN FOR 1980, LOWER MISSOURI SUBBASIN

Plan Features	Unit	Physical Measure		First Cost ($1,000)	
		Unconstrained	Constrained	Unconstrained	Constrained
Federally Financed Features					
Reservoir Modification	1,000 AF	16	0	5,700	0
Single-Purpose Flood Control	Miles	873	495	175,600	100,000
Grade Stabilization	Structures	877	330	29,700	10,050
Bank Stabilization	Miles	14	8	300	150
Multiple-Purpose Reservoirs	1,000 AF	6,352	4,400	522,000	332,620
Group Drainage	1,000 AC	40	24	1,000	480
Federal Land Conservation	1,000 AC	6	4	100	40
Fish Impoundments	Number	21	13	1,200	680
Scenic Rivers	Miles	35	35	900	900
Flood Plain Management	Reports	17	10	300	180
Non-Federal Costs (Initial)				53,500	30,000
Subtotal				790,300	475,100
Non-Federal Plan Features					
Non-Federal Irrigation	1,000 AC	230		23,400	
Recreation	1,000 AC	61		118,400	
Land Conservation	1,000 AC	1,445		134,000	
Sewage Treatment	Plants	388		73,000	
Water Supply & Treatment				115,000	
Fish & Wildlife Management	1,000 AC	87		17,300	
Flood Plain Management	1,000 AC	591		95,500	
Subtotal				576,600	
Subbasin Framework Total				1,366,900	

MISSOURI RIVER BASIN

Additional improvements, not presently underway, which may be required on the main stem of the Missouri River are projected to occur sometime after 1980 and therefore, provisions have not been made for near-term funding. Accordingly, table 129 reflects a summation of the constrained tributary framework plans for the 1980 level.

Table 129 – PROGRAMMED FRAMEWORK PLAN FOR 1980
MISSOURI BASIN

Plan Features	Unit	Physical Measure		First Cost ($1,000)	
		Unconstrained	Constrained	Unconstrained	Constrained
				(Thousand Dollars)	
Federally Financed Features					
Federal Land Recreation	1,000 AC	32	22	63,300	42,800
National Recreation Area	1,000 AC	37	20	17,000	9,400
Irrigation Rehabilitation				62,500	27,400
Wildlife Refuge Additions	Number	16	13	13,000	10,500
Fish Hatcheries & Impoundments	Number	99	51	18,500	14,680
Reservoir Modifications	1,000 AF	178	162	9,000	3,300
Single-Purpose Flood Control Reservoirs	1,000 AF	290	160	50,600	27,900
Local Flood Control	Miles	2,449	1,538	268,200	157,270
Hydro-power Facilities				147,200	41,400
Grade Stabilization	Structures	3,337	1,524	66,300	27,830
Bank Stabilization	Miles	537	224	9,200	4,150
Multiple-Purpose Reservoir and Associated Joint Works	1,000 AF	19,187	12,370	1,831,500	1,151,960
Federal Irrigation	1,000 AC	578	275	392,100	189,120
Group Drainage	1,000 AC	252	102	5,900	2,580
Federal Land Conservation	1,000 AC	2,072	1,855	12,900	10,900
Wildlife Wetlands	1,000 AC	1,146	1,014	56,600	44,300
Scenic Rivers	Miles	35	35	900	900
National Trails	Miles	2,475	2,070	21,600	11,400
Flood Plain Management	Reports	106	75	2,200	1,610
Forest Management	1,000 AF	117	59	500	200
Precipitation Management	1,000 AF	203	94	4,000	1,800
Non-Federal Costs (Initial)				119,700	72,500
Subtotal				3,172,700	1,853,900
Non-Federal Plan Features					
Non-Federal Irrigation	1,000 AC	2,157		503,400	
Recreation	1,000 AC	948		630,300	
Land Conservation	1,000 AC	29,571		978,000	
Reservoir Modifications	1,000 AF	209		36,500	
Sewage Treatment	Plants	1,938		335,000	
Water Supply & Treatment		---		510,900	
Single-Purpose Reservoir	1,000 AF	417		46,600	
Fish & Wildlife Management	1,000 AC	251		68,700	
Flood Plain Management	1,000 AC	879		204,000	
Subtotal				3,313,400	
Missouri Basin Total				6,486,100	

SUMMARY

The planning, programming, and budgeting analyses presented herein are based on the best information available at this time, and do reflect considerable judgment. The fiscal, as well as the physical constraints noted, are considered to be fairly reasonable assumptions. Further, in view of the reconnaissance scope of the study, the results are considered to be well within the accuracy expected of such studies. It is apparent, however, that the further planning, programming, and budgeting studies should be made as the plan is updated in the future and as more detailed resource studies are undertaken. The results of the studies that have been made provide the basis and direction for analyzing plan implementation requirements in the future.

Constraining of the 1980 framework plan will, of course, result in a lower level in the output of goods and services which were projected as "responses" to meet needs in the framework studies. However, under such constraints, the more critical "needs" would still be met, such as water supply for rural and municipal domestic requirements. If the lessened rate of population increase now projected in the new series of economic projections materializes, some dampening of needs at the 1980 level can be expected although these projections will have a more significant impact after that time. Although certain goods and services would be foregone at the 1980 level, the development of water and related land resources

would be at least equal to that over the last 10 years. Since economic projections used to define "needs" reflect a historical projection, there is no need to believe that the future (1980) economy would be significantly degraded because of the constrained plan. In fact, the opposite is likely to occur — a continuing enhancement of the social and economic well-being of the residents of the basin.

OTHER PLAN IMPLEMENTATION CONSIDERATIONS

Aside from fiscal, planning capability, and timing considerations, implementation of the regional or basin framework plan will require actions by the Federal, State, local, and private sectors. Such actions will be governed in part by institutional, policy, and legal arrangements in force at the time plan features are ready for implementation. A brief review of the institutional, policy, and legal arrangements and their relationships to the framework plan gives an insight to possible changes that may be required for plan implementation.

Institutional Arrangements

The comprehensive framework planning study for the Missouri River Basin was undertaken by the Missouri Basin Inter-Agency Committee, a regional institution. Such an institution provides a mechanism for undertaking joint-coordinated water resource planning. Within the MBIAC structure, or any future regional institution with similar responsibilities, it is possible to pool expertise, and more importantly, to articulate the planning goals and objectives for the basin as a whole, or for the various subbasins.

Since a comprehensive framework plan for the development of water and related land resources in the Missouri Basin is now available, and will be updated periodically, future water resource planning by individual agencies, Federal and non-Federal, should be compatible with the plan. Obviously, as detailed planning is undertaken in the future the current framework plan will be adjusted and up-dated in light of such planning. The framework plan, therefore, provides a basis for improving coordination during future detailed studies. To insure that future project proposals are in consonance with the framework plan, the MBIAC can provide the mechanism whereby fully coordinated water plans are formulated. Such a regional institution can provide for a good overview of proposals made by individual States and agencies, determine if all viewpoints have been considered, and resolve coordination differences that arise.

Of great significance are the institutional arrangements at the State and local level required to provide Federal agencies with assurances and to execute contractual arrangements for cost-sharing or cost-reimbursement over the long term. The problem here is one of many special local districts created to provide the mechanism to meet legal and contractural requirements. There is a need for the consolidation of local entities into larger units covering larger areas with authority to enter into necessary contractual arrangements, not only with the Federal Government, but with any other entity. A good example of such consolidation may be found in Nebraska. Recently, that State has enacted legislation that calls for the creation of not more than 28, nor fewer than 16, natural resources districts throughout the State for the purposes of effective coordination, planning, development, and general management of natural resources within the districts. The magnitude of such consolidation can be illustrated by the number of soil and water conservation districts, watershed conservancy districts, watershed districts, watershed advisory boards, and other similar institutions that will be consolidated. Currently there are 150 such organizations in existence. Many other entities may also be consolidated. Similar consideration may be desirable in other states.

Policy Considerations

Policies promulgated by institutions are usually based on interpretation of appropriate laws or are administratively determined if a specific law does not exist. The framework plan was formulated to meet certain objectives, all of which have economic as well as social implications. Traditionally, Federal agencies have relied on the concept of maximizing net benefits as their criterion in support of Congressional authorizations for project construction. At the regional and local level similar criteria are applied, except that economic efficiency at the local levels may be overriding. In recent years, both at Federal and non-Federal levels, environmental enhancements have been embraced as proper elements of a water plan. However, in this area, economic values are subjective and intangible and implementation is based, in part, on the principle of "willingness to pay."

The lack of clear-cut public policies and priorities at the national level has been recognized for some time. Senate Document 97, 87th Congress, Second Session, presented policies, procedures, and standards for the formulation of water and related land resources developments that were aimed at achieving unity in water resource planning. These are not being fully implemented at this time, primarily because of problems inherent in benefit evaluations and the primary reliance on national efficiency gains as the measure of the worth of specific proposals. However, the Water Resources Planning Act of 1965 reinforced the principle of unified

planning by establishing the institutional mechanism — the National Water Resources Council — for coordination of efforts at the highest level, and by emphasizing joint Federal-State cooperation in water resources planning. These actions have been partially successful in achieving the desired objectives. Moreover, steps have been initiated by the Water Resources Council toward resolving the problems cited. However, it must be recognized that until policies become more crystallized, agency dogmas are minimized, and acceptance of common goals is embraced, the formulation and implementation of comprehensive water plans can be constrained by such factors.

With a situation such as described, implementation of many framework plan features probably would require some changes in policy and laws. For example, in this framework plan, reservoir systems in tributary subbasins were formulated to meet a number of economic and social objectives. In some instances, individual units of the system may not meet national economic efficiency tests, although they may meet a combined national-regional economy efficiency test. Many outputs from the system could not be quantified, especially in terms of market values, and judgment values must be made as to whether the system is viable and should be implemented. Therefore, a need exists to reassess the evaluation procedures for water resource programs and the related institutional policies leading to recommendations for action, whether at the Federal, State, or local level.

As policies at all levels of government are more clearly articulated in the future, priorities for detailed planning of the framework plan features can proceed on a more orderly basis. Subsequent decisions for action would be made through the political process as they have been in the past, but probably with greater effectiveness. Under current policies there is little choice of action at the Federal level since favorable consideration for water development is limited to national economic gains. The role of the Federal Government in the water resources field must, therefore, be continually examined from many viewpoints — institution, economic, social, and the extent of cost participation — with similar assessments at the non-Federal levels.

Legal Considerations

State and Federal legislation, summarized briefly in chapter 4 and more fully documented in the appendix, "Laws, Policies and Administration Related to Water Resources Development," provides the base from which water resource developments, contracts, and agreements are implemented. The extent of the Federal involvement in project construction can normally be measured in terms of cost-sharing arrangements derived from legislation or policies adopted from the basic laws. Therefore, implementation of a majority of the framework plan features will depend not only on the capability and willingness of non-Federal institutions to pay, but also on the magnitude of Federal funds available at any given time.

Cost-sharing arrangements between Federal and non-Federal institutions has evolved through numerous Congressional legislative actions. For the most part, the *extent* of Federal cost participation in various water resources developments on a functional basis is not uniform. The guiding principle that costs should be borne in relation to benefits received may justify cost-sharing differences between functional uses, but it does not provide a sound rationale for differences between agencies dealing with the same functional use. A good illustration may be found in the field of municipal and industrial water supply where federally assisted developments can include participation by a number of Federal organizations. These include the Bureau of Reclamation, Corps of Engineers, Soil Conservation Service, Department of Housing and Urban Development, Public Health Service, Farmers Home Administration, and Economic Development Administration. Some administer grant programs, while others develop water supplies in conjunction with multiple-purpose storage impoundments within certain limitations. It is only logical that the extent of Federal cost involvement for the same level of services should be the same regardless of the Federal agency involved. There is a need, therefore, that cost-sharing arrangements between the Federal Government and non-Federal entities be reviewed to determine the practicability and feasibility of developing and applying uniform cost-sharing for individual water services.

Fundamental constraints to the formulation of the framework plan, or any other water resource plan for that matter, are the water rights in effect and administered by the States. Water rights have been a very useful legal tool for systematizing what might have been a nightmarish legal morass. If not properly designed, and from time to time reviewed and up-dated, water rights may discourage wise use of water; however, water rights do not automatically cause unwise water use.

Most existing surface water rights in the Missouri Basin that are now in effect and protected were based on past water-use technology. If applied, modern technology and investment may result in a requirement for less water to satisfy the existing rights, lower operation and maintenance costs, and additional water being made available for use in extending the same system or accomplishing greater water use elsewhere. Most State laws protect the presen. user, hence he has no incentive to make the investment and adopt the new technology. Educational programs should be undertaken and laws and incentives, such as technical and cost-sharing assistance, should be formulated to optimize the use of

water as opposed to maintenance of the status quo, particularly in water-short areas.

Also, many existing surface water rights have been granted that are no longer exercised, or were never fully developed. However, these rights are in full effect and thus may be put to use at any time. Most States in the basin have laws that govern water right abandonment for nonuse, but enforcement is not exercised unless a complaint is registered by other affected interests. Statutes should be enacted in some of the States whereby unexercised, adjudicated water rights can be deemed abandoned or forfeited by a simple procedure so that future development can proceed properly. In those States where the riparian doctrine is in effect, some form of appropriative doctrine will probably have to be adopted sometime in the future, especially as water supplies are diminished and competition develops for the residual flows.

The backbone of the framework plan includes tributary reservoir systems that provide for regulation of low flows for various beneficial purposes. However, in most basin States there is no legal protection of storage releases or of natural streamflows for such environmental purposes as fish, wildlife, recreation, or water quality. In many areas of the basin, these environmental purposes would be enhanced by implementation of the framework plan features only because of the regulation of low flows for those beneficial purposes which are recognized under the State water laws. Obviously, the key here is to enhance water quality and the maintenance of stream quality within adopted standards.

This leads to a more complex question as to what constitutes governing criteria with respect to water quality. In the framework study, it was assumed that secondary sewage treatment and even higher levels of sewage treatment would be adopted to achieve biochemical oxygen demand removals to a 95-percent level by 2020. This reflects an approach to prevent organic pollution at its source. However, in a number of reaches of the basin's streams seasonal low flows are not sufficient to assimilate treated wastes and thus maintain stream quality standards. Therefore, other measures such as low-flow augmentation and offstream ponds may also be needed. In essence, while the public generally is concerned about water quality degradation, the causes, degrees, and effects of degradation are not well known. There is a need for additional data and analysis in order to establish a solid technical base as a prerequisite to implementation of actions necessary for improving water quality. As discussed in chapter 8, dissolved solids concentration above desirable levels, although not necessarily beyond usable limits, are inevitable with increasing consumptive uses of water. This further high-lights the complexities of striving for water quality enhancement and ideally setting goals of non-degradation of existing stream quality that may not be possible of achievement. Accordingly, there is an urgent need to analyze all forms of potential stream pollution and the means of attaining reasonable solutions. In all probability, regional systems encompassing structural measures and managerial (institutional and legal) actions will be required to cope with the problems of water quality.

In spite of the questions raised, there is a need for the States to define "beneficial use" and to clarify the means by which storage water releases and any natural flows that may be dedicated to beneficial uses can be protected. Compacts and court decrees have been consummated regulating the division and use of water from many streams between States of the basin. As documented to date, the use has dealt primarily with quantity and very little or no reference has been made to quality, either organic or inorganic. Enactment of the Federal Water Pollution and Clean Water Restoration Acts in the mid 1960's has resulted in the adoption of State Water Quality Standards generally, and the protection of the quality of water in interstate streams. While these two laws in no way do so, the standards adopted and their fulfillment under State administration could affect the existing decrees of quantity use. While not clear at this time, there appears to be a need for clarification of this relationship on each interstate stream affected. Future compacts and decrees need to specify clearly the interstate water quality as well as quantity considerations. The consent of the Congress has been granted in this legislation for two or more affected states to negotiate and enter into agreements or compacts for the prevention and control of pollution on interstate streams.

Another area of concern with respect to water rights deals with water emanating from or available on federally owned lands. A considerable volume of streamflow emanates from federally owned lands in the basin.

One viewpoint holds that when lands were reserved from the public domain, the United States impliedly reserved water sufficient for use in accordance with the purposes for which the lands were reserved and as of the date of land withdrawal. Historically, and in the future, the waters leaving these reservation areas have been, or may be, dedicated to specific use under rights which have, or may be, granted within the framework of State laws and continuing administration. Added uses on the Federal lands may not conform with the State water-right structures and there would be a cloud on the validity of State-granted rights. Thus there is need for a final determination concerning the Federal reserved water doctrine, as by the United States Congress, and means should be developed to quantify the water-use requirements of lands reserved from the public domain so that other water rights can be safely and firmly established. Quantification of such requirements already is in progress on some reserved lands.

A related and similar situation exists with respect to Indian lands. The Indians on the reservations have some claim to the use of waters which are located on, or which flow through or along the boundaries of the Indian reservation. Indian water rights are read from the treaties and agreements between Indian tribes and the United States which have been approved by Acts of Congress or formalized by Executive Orders. Indian water rights normally have a priority as of the date on which the Indian reservation was established, maintain their validity even though unexercised, and are held superior to State-granted rights. Some Missouri River Basin States are not in agreement with this position. Further, many Indian tribes and their attorneys hold that Indian rights are aboriginal in character; are affirmed by the courts; and do not have limits. Such reserved rights that can be used at any time constitute a deterrent to development by other-than-Indian interests, both upstream and downstream from Indian lands. Such rights can be quantified by fixing the amount of water needed to serve the purposes for which the Indian reservation was established. Thus, if the purpose of the reservation was to promote an agricultural economy, as has generally been the case, the quantity of water reserved would be the amount needed to serve the practically irrigable acreage on the reservation. The use of such rights for non-irrigation purposes has not been judicially questioned or ruled upon. Judicial decisions or legislative actions are necessary to settle the points of disagreement regarding the reserved water rights of the Indians. Once the legal questions have been clarified, the reserved water rights can be quantified, thereby permitting the development of the uncommitted water resources to proceed safely.

The relationship of surface and ground waters is also ambiguous at this time. More and more there is physical evidence, but a lack of general understanding, in the establishment of operational and legal relationships between surface and ground water uses and rights. It was recognized in the framework plan that ground-water depletions in some instances already deplete streamflows for which there are existing water rights, and other surface water rights are dependent in part on ground water inflow to the streams. For some areas, the full realization of benefits from water resource development will require the conjunctive use of both surface waters and ground waters, and protection for those making the investments for this purpose.

Heavy withdrawals of ground water from an aquifer often result in lowering the water table in that aquifer. The aquifer may have many existing users with satisfactory wells that initially penetrate the aquifer only to a partial depth. Thus, lowering the water level through mounting usage may require these existing users to reconstruct their wells to maintain the existing use capability. In this regard, excessively restrictive laws to protect existing water users could be a barrier to optimum use of the resource.

In facing up to the need for fuller utilization of the available water supplies, certain of the basin States have considered the need and adopted legal and policy structures that permit the movement of water between their basins and its use intrastate. In other States, the authority to accomplish such movement and use of water has been questioned legally and contested in the courts. As the high-preference demands grow in magnitude and within-basin water supplies approach full utilization, there will be the need for well-considered legislation, policy, and intrabasin developments in most, if not all, States of the basin. Areas of origin are entitled to full protection for foreseeable beneficial uses, and it is quite possible that safeguards also can be established for the unforeseeable future to assist in the financing of future water development in areas of origin. The framework plan does include plan features for the diversion of surface water from the Niobrara River drainage to the Platte River system in Nebraska and from the latter to the Kansas River drainage in Nebraska. The indicated need for such trans-basin diversions is placed at sometime after the year 2000, although it could be implemented earlier. Obviously, the legal considerations already cited must be faced and action taken if such diversion proposals are to be implemented.

The framework plan includes features for the development of over 5 million acres of land for surface-water irrigation. A significant portion of this development will be undertaken as projects through the provisions of the Reclamation Act, or water made available that may be subject to its provisions. Reclamation law and amendments limit the acreage of land in the ownership of one person or corporation that may receive project water service to 160 irrigable acres. In the case of joint ownership, as for man and wife, the limitation is 320 irrigable acres. This law applies to the 17 western states, excluding only Minnesota, Iowa, and Missouri in the Missouri River Basin. There is a growing recognition that in many areas within the Missouri Basin, and elsewhere, a 160-acre or a 320-acre farm unit is not the most economical operation, particularly in relation to productive capability of the lands, limitations in potential crops, and the cost of maintaining a modern competitive, mechanized operation. There appears to be a need for equitable and consistent legislative action regarding the acreage that can be served from any federally constructed water facility, regardless of the program under which it is developed.

In essence, the acreage limitation set forth in reclamation law appears outmoded. Increased production costs coupled with decreased profit margins clearly point toward a need for larger irrigated farming units. The acreage limitation might have some merit in the Missouri Basin if it could dampen the out-migration from the

rural areas (if this were a social objective). However, the limitation does not appear to provide any particular incentive for individuals to remain on the farm and may even discourage those who might otherwise be amenable to continuing in irrigated agriculture. It may well be more appropriate to treat agricultural water supply from a water project as a commodity that can be marketed, with economic factors governing sales rather than artificially imposed conditions. If subsidies are required to meet certain social or economic goals, these could readily be accommodated within the pricing structure for the water supply.

The remaining significant area of concern that is affected by existing laws and policies deals with land programs. In general, the primary emphasis here is on environmental preservation and enhancement, but with important economic considerations. Preservation of wetlands, zoning of cities for aesthetic purposes, the potential for increasing hunting opportunities, and similarly-related items are sensitive to legal matters and fundamental to economic returns to property owners. Other than the wildlife wetlands program, these matters are generally of local concern and will have to be resolved by State and local units of government.

The management of resident wildlife and fish and the regulation of hunting and fishing seasons is the right and responsibility of State Government except on Indian lands or Federal lands on which Congress has specifically reserved all hunting and fishing rights. The State Game and Fish Departments work closely with private land owners, State land-holding agencies, Indian tribal councils, and Federal land-holding agencies to encourage the protection and enhancement of lands suitable for wildlife habitat. One of the greatest potentials is in providing tax or payment incentives to the private sector, primarily farmers, to increase habitat and provide for hunting opportunities. Also, there is a pressing need to increase funds available to Federal land-administering agencies for the same purposes. The demands and needs as estimated for the framework study thus would adjust to the level indicated by the willingness of the public to structure State and local laws, together with adequate financing, to provide necessary habitat to support given levels of fishing and hunting or other recreation opportunities.

The Wildlife Wetlands program, on the other hand, transcends local areas. There are water and marsh areas in private ownership that provide valuable wildlife habitat (primarily migratory waterfowl) of national and international significance. These areas in their present condition supply a relatively low monetary return to the owner, but by draining and leveling certain areas they can be converted to economically productive cropland. There is a considerable acreage drained each year which is reducing the available habitat, with a corresponding reduction in migratory waterfowl. To reverse this trend there is a need to expand Federal and State programs to compensate private land owners for the preservation and enhancement of water and marsh-area wildlife habitat.

Probably one of the more significant programs to be implemented at the State-local level by the framework plan is the "flood plain land use management" that should be accomplished in the future. The primary emphasis here is to dampen and reduce the increase in flood damages caused by unwise flood plain occupancy. Such a program requires a delineation of the flood hazard areas, establishment of the degree of flood risk, and the formulation of comprehensive land use plans. It is in the latter item that a significant opportunity could be seized upon for environmental enhancement. As indicated by the framework plan, about 2.2 million acres of agricultural and open space flood plain lands could be converted to less intensive agricultural use, recreation, wildlife, and general environmental enhancement and at the same time minimize flood losses. Obviously, a considerable number of technical studies is required before implementation can be initiated. Just as obvious, implementation of State and local level will require legal, institutional, and funding arrangements to make this possible.

Flood plain management is reflected by proper and wise land use and the willingness and ability of the affected government to regulate such use — this means public acceptance. The most pressing near-term need is the development of technical information defining the flood risks on the flood plains and concurrent land use studies of these areas. Not only must floodways be defined, but land use and controls must be explored from many standpoints. Structural control of flooding must be recognized, alternative land use patterns established, costs determined, and choices made as to a proper course of action. This undoubtedly will be a time-consuming process, require significant funding for technical studies, and require accelerated funding levels for implementation. It will take a concerted effort on the part of all levels of government, and most importantly, will require a legal structure and good administration to enforce the land use controls.

The discussion of institutional, policy, and legal considerations has been limited to the more significant items that affect the development and implementation of water and related land resource plans. The framework plan presented in this appendix does embody, to the extent possible at this time, elements that provide for resource developments considered to be in the best interest of the basin. The framework plan is flexible, it will have to be continually up-dated, and elements will be implemented at the proper time. This can be accomplished only if legal, institutional, and policy arrangements also are up-dated and thus are made responsive to the progressive needs and objectives of the basin and Nation.

Many Levels of Government Are Concerned With
Water Resources Development

COST DISTRIBUTION SUPPLEMENT
TABLE DESCRIPTIONS

The following information is provided to supplement data given in the preceding appendix, with five sets of tables as described:

Table S1 – FUNCTIONAL COST DISTRIBUTION – MISSOURI BASIN FRAMEWORK PLAN

Function & Time Frame	Subbasins								
	Upper Missouri	Yellowstone	Western Dakota	Eastern Dakota	Platte-Niobrara	Middle Missouri	Kansas	Lower Missouri	Missouri Basin
(Cumulative Above Current)	($ Millions)								
Irrigation									
1980	180.6	200.0	85.4	118.4	408.3	62.0	187.2	38.6	1,280.5
2000	363.0	457.7	177.5	354.5	773.2	196.6	858.0	87.5	3,268.0
2020	482.4	629.9	300.3	877.1	1,159.1	383.7	1,062.5	127.5	5,022.5
Land Conservation									
1980	85.8	66.9	93.9	115.1	236.0	77.0	182.1	134.1	990.9
2000	234.8	164.8	225.2	300.2	533.0	187.1	432.3	310.3	2,387.7
2020	383.6	267.9	344.3	475.3	856.5	328.1	687.4	507.4	3,850.5
Recreation									
1980	174.1	117.8	69.4	37.4	261.6	140.5	118.6	196.9	1,116.3
2000	323.3	305.3	198.7	156.6	536.5	311.7	233.9	586.2	2,652.2
2020	515.7	514.7	265.5	364.7	1,012.1	522.0	372.0	1,001.6	4,568.3
Flood Control									
1980	29.8	15.8	15.6	68.0	180.9	85.3	160.4	499.4	1,055.2
2000	4[illegible].4	26.1	70.4	107.9	299.4	161.9	291.3	752.9	1,755.3
2020	5[illegible].4	43.1	72.9	129.5	327.7	223.1	390.8	799.1	2,042.6
Water Supply and Treatment									
1980	24.4	14.0	22.2	53.4	161.3	74.6	121.2	161.8	632.9
2000	48.1	39.3	49.8	120.0	466.3	150.0	273.9	317.5	1,464.9
2020	75.1	66.5	73.8	176.8	672.6	219.8	418.5	456.5	2,159.6
Pollution Abatement									
1980	24.9	12.0	18.0	54.9	83.0	59.8	62.6	99.3	414.5
2000	43.4	24.0	35.0	104.5	182.1	109.5	127.5	192.5	818.5
2020	79.4	36.0	59.0	156.8	271.4	156.2	209.5	318.8	1,287.1
Flood Plain Management									
1980	1.2	7.2	0.3	9.4	51.9	18.4	22.0	95.8	206.2
2000	5.8	11.1	4.5	28.5	136.0	88.2	60.8	194.5	529.4
2020	9.5	60.6	18.6	38.4	189.1	103.4	109.1	210.7	739.4
Fish and Wildlife									
1980	19.9	11.4	17.9	86.3	71.9	33.5	17.2	68.2	326.3
2000	38.1	25.2	29.7	95.8	125.6	51.3	32.0	135.5	533.2
2020	50.2	42.4	37.7	110.6	153.7	61.4	48.9	150.6	655.5
Hydro-Power									
1980	109.6	0	0	0	208.4	0	0	33.3	351.3
2000	109.6	0	0	0	413.4	0	0	33.3	556.3
2020	109.6	0	0	0	483.4	0	0	33.3	626.3
Erosion Control									
1980	1.0	1.1	1.2	4.8	1.6	37.5	11.2	37.5	95.9
2000	3.1	3.9	3.1	7.8	4.9	100.2	16.8	57.5	197.3
2020	4.1	7.2	13.9	9.0	8.1	168.6	21.5	63.1	295.5
Group Drainage									
1980	0	0	0.9	1.4	6.4	0.2	0.7	2.0	11.6
2000	0	0	1.1	45.5	9.7	2.0	3.1	3.5	64.9
2020	0	0	1.1	45.5	15.0	4.0	3.7	5.0	74.3
Forest & Precipitation Management									
1980	0.5	2.0	0	0	2.0	0	0	0	4.5
2000	3.2	9.7	0.1	0	6.3	0	0	0	19.3
2020	8.4	20.7	0.1	0	16.0	0	0	0	45.2
Total of Subbasins									
1980	651.8	448.2	324.8	549.1	1,673.3	588.8	883.2	1,366.9	6,486.1
2000	1,217.8	1,067.1	795.1	1,321.3	3,486.4	1,358.5	2,329.6	2,671.2	14,247.0
2020	1,774.4	1,689.0	1,187.2	2,383.7	5,164.7	2,170.3	3,323.9	3,673.6	21,366.8
Missouri River Improvements									
1980									0.0
2000									90.0
2020									3,090.0
Total Missouri River Basin									
1980									6,486.1
2000									14,337.0
2020									24,456.8

Table S2 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY UPPER MISSOURI SUBBASIN — 1965 TO 1980 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						0		0
State & Local Recreation						143.1	57.1	86.0
National Recreation Area								
Private Land Conservation						84.0	42.0	42.0
Irrigation Rehabilitation	12.8	12.8		12.8				
Access						2.7		2.7
Refuges	1.1	1.1						
Hatcheries	.2	.1			.1			
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	7.4	5.9			1.5			
Other Single Purpose Res.						3.0		3.0
Grade Stabilization								
Bank Stabilization	1.0	.7			.3			
M. P. Reservoirs	223.0	(118.4)	(104.6)	(154.8)				
Water Quality			7.9					
Irrigation			34.6	34.6				
M & I			6.6	6.6				
Power		88.0	21.6	109.6				
Recreation		8.0	17.0	4.0				
Fish and Wildlife			16.9					
Flood Control		22.4						
Surface Water Irrigation	133.2	133.2		133.2				
Group Drainage								
Public Land Conservation	1.8	1.8						
Environ. and Non-Structural								
Sewage Treatment						17.0	5.1	11.9
Water Supply & Treatment						17.8	8.9	8.9
Fish and Wildlife								
Wetlands	1.0	.9			.1			
Management Areas						.7	.4	.3
Fish Hatcheries								
Fish Impoundments								
Scenic Rivers								
Trails	.3	.3						
Flood Plain Management	.1	.1				1.1		1.1
Forest Management	.1	.1						
Precip. Management	.4	.4						
Totals	382.4	275.8	104.6	300.8	2.0	269.4	113.5	155.9

1965-1980 Total: 651.8

Table S3 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY UPPER MISSOURI SUBBASIN – 1980 TO 2000 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						7.2		7.2
State & Local Recreation						123.0	49.2	73.8
National Recreation Area								
Private Land Conservation						144.0	72.0	72.0
Irrigation Rehabilitation	15.2	15.2		15.2				
Access						3.6		3.6
Refuges	3.7	3.7						
Hatcheries								
Reservoirs						.5		.5
Water Control and Related Land								
Single Purpose F. C.	.6	.5			.1			
Other Single Purpose Res.						2.5		2.5
Grade Stabilization								
Bank Stabilization	2.1	1.5			.6			
M. P. Reservoirs	79.0	(24.0)	(55.0)	(39.0)				
Water Quality			1.5					
Irrigation			33.0	33.0				
M & I			1.5	1.5				
Power								
Recreation		9.0	9.5	4.5				
Fish and Wildlife			9.5					
Flood Control		15.0						
Surface Water Irrigation	126.5	126.5		126.5				
Group Drainage								
Public Land Conservation	5.0	5.0						
Environ. and Non-Structural								
Sewage Treatment						17.0	5.1	11.9
Water Supply & Treatment						22.2	11.1	11.1
Fish and Wildlife								
Wetlands	1.7	1.6			.1			
Management Areas						3.3	1.7	1.6
Fish Hatcheries								
Fish Impoundments								
Scenic Rivers	1.4	1.4						
Trails	.2	.2						
Flood Plain Management	.1	.1				4.5		4.5
Forest Management	.3	.3						
Precip. Management	2.4	2.4						
Incremental Totals	238.2	182.4	55.0	180.7	.8	327.8	139.1	188.7
Cumulative Totals	620.6	458.2	159.6	481.5	2.8	597.2	252.6	344.6

1980-2000 Total: 566.0

Table S4 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY UPPER MISSOURI SUBBASIN — 2000 TO 2020 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						6.0		6.0
State & Local Recreation						158.8	63.5	95.3
National Recreation Area								
Private Land Conservation						146.0	73.0	73.0
Irrigation Rehabilitation	14.3	14.3		14.3				
Access						4.3		4.3
Refuges								
Hatcheries								
Reservoirs						1.0		1.0
Water Control and Related Land								
Single Purpose F. C.								
Other Single Purpose Res.						9.4		9.4
Grade Stabilization								
Bank Stabilization	1.0	.7			.3			
M. P. Reservoirs	61.0	(23.0)	(38.0)	(26.8)				
Water Quality			4.0					
Irrigation			17.7	17.7				
M & I			3.1	3.1				
Power								
Recreation		12.0	6.6	6.0				
Fish and Wildlife			6.6					
Flood Control		11.0						
Surface Water Irrigation	80.4	80.4		80.4				
Group Drainage								
Public Land Conservation	2.8	2.8						
Environ. and Non-Structural								
Sewage Treatment						32.0	9.6	22.4
Water Supply & Treatment						23.9	11.9	12.0
Fish and Wildlife								
Wetlands	3.0	2.9			.1			
Management Areas						2.5	1.3	1.2
Fish Hatcheries								
Fish Impoundments								
Scenic Rivers	1.3	1.3						
Trails								
Flood Plain Management	.4	.4				3.3		3.3
Forest Management	.5	.5						
Precip. Management	4.7	4.7						
Incremental Totals	169.4	131.0	38.0	121.5	.4	387.2	159.3	227.9
Cumulative Totals	790.0	589.2	197.6	603.0	3.2	984.4	411.9	572.5

2000-2020 Total: 556.6

Table S5 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
YELLOWSTONE SUBBASIN — 1965 TO 1980 PERIOD

Function	Plan Features With Initial Federal Investment ($ Millions)					Non-Federal Plan Features ($ Millions)		
			Allocated	(Non-Federal)				
	Total	Specific	Joint	Repayable	Cost-Share	Total	Fed. Grants & Assistance	Local
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						1.8		1.8
State & Local Recreation						88.4	35.3	53.1
National Recreation Area								
Private Land Conservation						63.0	31.5	31.5
Irrigation Rehabilitation	11.6	11.6		11.6				
Access						.1		.1
Refuges								
Hatcheries								
Reservoirs						35.9		35.9
Water Control and Related Land								
Single Purpose F. C.	5.0	4.0			1.0			
Other Single Purpose Res.								
Grade Stabilization	.3	.2			.1			
Bank Stabilization	.8	.6			.2			
M. P. Reservoirs	60.0	(24.1)	(35.9)	(33.1)				
Water Quality								
Irrigation			22.1	22.1				
M & I								
Power								
Recreation		22.0	6.9	11.0				
Fish and Wildlife			6.9					
Flood Control		2.1						
Surface Water Irrigation	31.1	31.1		31.1		106.2		106.2
Group Drainage								
Public Land Conservation	3.9	3.9						
Environ. and Non-Structural								
Sewage Treatment						12.0	3.6	8.4
Water Supply & Treatment						14.0	7.0	7.0
Fish and Wildlife								
Wetlands								
Management Areas						3.2	1.6	1.6
Fish Hatcheries	1.3	.7			.6			
Fish Impoundments								
Scenic Rivers								
Trails	.4	.4						
Flood Plain Management	.1	.1				7.1		7.1
Forest Management	.2	.2						
Precip. Management	1.8	1.8						
Totals	116.5	78.7	35.9	75.8	1.9	331.7	79.0	252.7

1965-1980 Total: 448.2

Table S6 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
YELLOWSTONE SUBBASIN – 1980 TO 2000 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						3.7		3.7
State & Local Recreation						154.3	61.7	92.6
National Recreation Area								
Private Land Conservation						88.0	44.0	44.0
Irrigation Rehabilitation	29.2	29.2		29.2				
Access						.2		.2
Refuges								
Hatcheries	.7	.4			.3			
Reservoirs	9.9	9.9						
Water Control and Related Land								
Single Purpose F. C.	6.9	5.5			1.4			
Other Single Purpose Res.								
Grade Stabilization	1.1	.9			.2			
Bank Stabilization	1.7	1.2			.5			
M. P. Reservoirs	72.0	(24.4)	(47.6)	(40.7)				
Water Quality								
Irrigation			28.9	28.9				
M & I			1.3	1.3				
Power								
Recreation		21.0	8.7	10.5				
Fish and Wildlife			8.7					
Flood Control		3.4						
Surface Water Irrigation	34.5	34.5		34.5		151.5		151.5
Group Drainage								
Public Land Conservation	9.9	9.9						
Environ. and Non-Structural								
Sewage Treatment						12.0	3.6	8.4
Water Supply & Treatment						24.0	12.0	12.0
Fish and Wildlife								
Wetlands								
Management Areas						4.4	2.2	2.2
Fish Hatcheries								
Fish Impoundments								
Scenic Rivers	3.2	3.2						
Trails	.1	.1						
Flood Plain Management	.2	.2				3.7		3.7
Forest Management	.5	.5						
Precip. Management	7.2	7.2						
Incremental Totals	177.1	127.1	47.6	104.4	2.4	441.8	123.5	318.3
Cumulative Totals	293.6	205.8	83.5	180.2	4.3	773.5	202.5	571.0
				1980-2000 Total:	618.9			

Table S7 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
YELLOWSTONE SUBBASIN — 2000 TO 2020 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						1.8		1.8
State & Local Recreation						193.4	77.4	116.0
National Recreation Area								
Private Land Conservation						97.0	48.5	48.5
Irrigation Rehabilitation	19.7	19.7		19.7				
Access						.3		.3
Refuges								
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.								
Other Single Purpose Res.								
Grade Stabilization	2.5	2.0			.5			
Bank Stabilization	.8	.6			.2			
M. P. Reservoirs	69.0	(23.0)	(46.0)	(29.6)				
Water Quality								
Irrigation			18.4	18.4				
M & I			8.2	8.2				
Recreation		6.0	9.7	3.0				
Fish and Wildlife			9.7					
Flood Control		17.0						
Surface Water Irrigation	38.7	38.7		38.7		93.6		93.6
Group Drainage								
Public Land Conservation	6.1	6.1						
Environ. and Non-Structural								
Sewage Treatment						12.0	3.6	8.4
Water Supply & Treatment						19.0	9.5	9.5
Fish and Wildlife								
Wetlands								
Management Areas						6.2	3.1	3.1
Fish Hatcheries	1.3	.7			.6			
Fish Impoundments								
Scenic Rivers								
Trails								
Flood Plain Management	.9	.9				48.6		48.6
Forest Management	.1	.1						
Precip. Management	10.9	10.9						
Incremental Totals	150.0	102.7	46.0	88.0	1.3	471.9	142.1	329.8
Cumulative Totals	443.6	308.5	129.5	268.2	5.6	1,245.4	344.6	900.8

2000-2020 Total: 621.9

Table S8 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
WESTERN DAKOTA SUBBASIN – 1965 TO 1980 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						1.4		1.4
State & Local Recreation						23.8	9.5	14.3
National Recreation Area	8.9	8.9						
Private Land Conservation						91.0	45.5	45.5
Irrigation Rehabilitation	5.9	5.9		5.9				
Access						.1		.1
Refuges	2.0	2.0						
Hatcheries	.5	.3			.2			
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	2.2	1.8			.4			
Other Single Purpose Res.						.2		.2
Grade Stabilization	.4	.3			.1			
Bank Stabilization	.8	.6			.2			
M. P. Reservoirs	105.0	(26.4)	(78.6)	(58.1)				
Water Quality								
Irrigation			50.4	50.4				
M & I			1.2	1.2				
Power								
Recreation		13.0	13.5	6.5				
Fish and Wildlife			13.5					
Flood Control		13.4						
Surface Water Irrigation	3.7	3.7		3.7		24.0		24.0
Group Drainage	.9	.5			.4			
Public Land Conservation	2.9	2.9						
Environ. and Non-Structural								
Sewage Treatment						18.0	5.4	12.6
Water Supply & Treatment						21.0	10.5	10.5
Fish and Wildlife								
Wetlands								
Management Areas						.4	.2	.2
Fish Hatcheries	1.1	.6			.5			
Fish Impoundments	.2	.1			.1			
Scenic Rivers								
Trails	10.1	10.1						
Flood Plain Management	.1	.1				.2		.2
Forest Management								
Precip. Management								
Totals	144.7	64.2	78.6	67.7	1.9	180.1	71.1	109.0
				1965-1980 Total:	324.8			

Table S9 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
WESTERN DAKOTA SUBBASIN – 1980 TO 2000 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						6.4		6.4
State & Local Recreation						66.0	26.4	39.6
National Recreation Area	19.0	19.0						
Private Land Conservation						124.0	62.0	62.0
Irrigation Rehabilitation	.8	.8		.8				
Access						.1		.1
Refuges								
Hatcheries								
Reservoirs	.6	.6						
Water Control and Related Land								
Single Purpose F. C.								
Other Single Purpose Res.								
Grade Stabilization	.3	.2			.1			
Bank Stabilization	1.6	1.1			.5			
M. P. Reservoirs	148.0	(89.8)	(58.2)	(55.3)				
Water Quality								
Irrigation			37.8	37.8				
M & I								
Power								
Recreation		34.0	10.2	17.0				
Fish and Wildlife		1.0	10.2	.5				
Flood Control		54.8						
Surface Water Irrigation	25.5	25.5		25.5		21.6		21.6
Group Drainage	.2	.1			.1			
Public Land Conservation	7.3	7.3						
Environ. and Non-Structural								
Sewage Treatment						17.0	5.1	11.9
Water Supply & Treatment						27.0	13.5	13.5
Fish and Wildlife								
Wetlands								
Management Areas						.4	.2	.2
Fish Hatcheries								
Fish Impoundments	.2	.1			.1			
Scenic Rivers								
Trails								
Flood Plain Management	.4	.4				3.8		3.8
Forest Management	.1	.1						
Precip. Management								
Incremental Totals	204.0	145.0	58.2	81.6	.8	266.3	107.2	159.1
Cumulative Totals	348.7	209.2	136.8	149.3	2.7	446.4	178.3	268.1
			1980-2000 Total: 470.3					

Table S10 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
WESTERN DAKOTA SUBBASIN – 2000 TO 2020 PERIOD

	Plan Features With Initial Federal Investment					*Non-Federal Plan Features*		
			Allocated	(Non-Federal)			Fed. Grants	
Function	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						16.0		16.0
State & Local Recreation						39.8	15.9	23.9
National Recreation Area								
Private Land Conservation						115.0	57.5	57.5
Irrigation Rehabilitation	.2	.2		.2				
Access								
Refuges								
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.								
Other Single Purpose Res.								
Grade Stabilization	10.0	8.0			2.0			
Bank Stabilization	.8	.6			.2			
M. P. Reservoirs	62.0	(22.5)	(39.5)	(35.5)				
Water Quality								
Irrigation			25.5	25.5				
M & I								
Power								
Recreation		20.0	7.0	10.0				
Fish and Wildlife			7.0					
Flood Control		2.5						
Surface Water Irrigation	25.3	25.3		25.3		55.8		55.8
Group Drainage								
Public Land Conservation	4.1	4.1						
Environ. and Non-Structural								
Sewage Treatment						24.0	7.2	16.8
Water Supply & Treatment						24.0	12.0	12.0
Fish and Wildlife								
Wetlands								
Management Areas						.8	.4	.4
Fish Hatcheries								
Fish Impoundments	.2	.1			.1			
Scenic Rivers								
Trails								
Flood Plain Management	.5	.5				13.6		13.6
Forest Management								
Precip. Management								
Incremental Totals	103.1	61.3	39.5	61.0	2.3	289.0	93.0	196.0
Cumulative Totals	451.8	270.5	176.3	210.3	5.0	735.4	271.3	464.1
				2000-2020 Total:	392.1			

Table S11 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
EASTERN DAKOTA SUBBASIN – 1965 TO 1980 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						14.4		14.4
State & Local Recreation						2.8	1.1	1.7
National Recreation Area	8.1	8.1						
Private Land Conservation						115.0	57.5	57.5
Irrigation Rehabilitation								
Access						.1		.1
Refuges	4.3	4.3						
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	44.5	35.6			8.9			
Other Single Purpose Res.	6.9	6.9				1.3		1.3
Grade Stabilization	4.6	3.7			.9			
Bank Stabilization	.2	.1			.1			
M. P. Reservoirs	77.0	(33.5)	(43.5)	(23.0)				
Assoc. Joint Works	70.0		(70.0)	(68.5)				
Water Quality			12.9					
Irrigation			80.1	80.1				
M & I			6.4	6.4				
Power								
Recreation		10.0	6.3	5.0				
Fish and Wildlife			7.8					
Flood Control		23.5						
Surface Water Irrigation	5.7	5.7		5.7		18.2		18.2
Group Drainage	1.4	.7			.7			
Public Land Conservation	.1	.1						
Environ. and Non-Structural								
Sewage Treatment						42.0	12.6	29.4
Water Supply & Treatment						47.0	23.5	23.5
Fish and Wildlife								
Wetlands	55.6	52.8			2.8			
Management Areas						5.8	2.9	2.9
Fish Hatcheries								
Fish Impoundments	4.6	2.3			2.3			
Scenic Rivers								
Trails	10.1	10.1						
Flood Plain Management	.2	.2				9.2		9.2
Forest Management								
Precip. Management								
Totals	293.3	164.1	113.5	97.2	15.7	255.8	97.6	158.2

1965-1980 Total: 549.1

Table S12 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY EASTERN DAKOTA SUBBASIN — 1980 TO 2000 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods								
Pvt. Grd. Water Irrigation						20.5		20.5
State & Local Recreation						51.6	20.7	30.9
National Recreation Area	18.2	18.2						
Private Land Conservation						185.0	92.5	92.5
Irrigation Rehabilitation								
Access						.1		.1
Refuges								
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	2.5	2.0			.5			
Other Single Purpose Res.	.2	.2				6.4		6.4
Grade Stabilization	2.8	2.3			.5			
Bank Stabilization	.2	.1			.1			
M. P. Reservoirs	90.0	(74.8)	(15.2)	(24.6)				
Assoc. Joint Works	177.0		(177.0)	(167.6)				
Water Quality			5.6					
Irrigation			168.6	168.6				
M & I			4.6	4.6				
Power								
Recreation		38.0	5.6	19.0				
Fish and Wildlife			7.2					
Flood Control		36.8	.6					
Surface Water Irrigation	20.2	20.2		20.2		26.8		26.8
Group Drainage	44.1	22.1			22.0			
Public Land Conservation	.1	.1						
Environ. and Non-Structural								
Sewage Treatment						44.0	13.2	30.8
Water Supply & Treatment						62.0	31.0	31.0
Fish and Wildlife								
Wetlands								
Management Areas								
Fish Hatcheries								
Fish Impoundments	1.0	.5			.5			
Scenic Rivers								
Trails	.4	.4						
Flood Plain Management	.3	.3				18.8		18.8
Forest Management								
Precip. Management								
Incremental Totals	357.0	141.2	192.2	212.4	23.6	415.2	157.4	257.8
Cumulative Totals	650.3	305.3	305.7	309.6	39.3	671.0	255.0	416.0

1980-2000 Total: 772.2

Table S13 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
EASTERN DAKOTA SUBBASIN – 2000 TO 2020 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						34.0		34.0
State & Local Recreation						163.7	65.5	98.2
National Recreation Area								
Private Land Conservation						175.0	87.5	87.5
Irrigation Rehabilitation								
Access								
Refuges								
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	2.5	2.0			.5			
Other Single Purpose Res.	7.0	7.0				6.4		6.4
Grade Stabilization	1.0	.8			.2			
Bank Stabilization	.2	.1			.1			
M. P. Reservoirs	56.0	(54.3)	(1.7)	(18.0)				
Assoc. Joint Works	332.0		(322.0)	(313.8)				
Water Quality			.3					
Irrigation			306.0	306.0				
M & I			7.8	7.8				
Power								
Recreation		36.0	3.0	18.0				
Fish and Wildlife			5.8					
Flood Control		18.3	.8					
Surface Water Irrigation	133.4	133.4		133.4		49.2		49.2
Group Drainage								
Public Land Conservation	.1	.1						
Environ. and Non-Structural								
Sewage Treatment						52.0	15.6	36.4
Water Supply & Treatment						49.0	24.5	24.5
Fish and Wildlife								
Wetlands								
Management Areas								
Fish Hatcheries								
Fish Impoundments	1.0	.5			.5			
Scenic Rivers								
Trails								
Flood Plain Management	.3	.3				9.6		9.6
Forest Management								
Precip. Management								
Incremental Totals	523.5	198.5	323.7	465.2	1.3	538.9	193.1	345.8
Cumulative Totals	1,173.8	503.8	629.4	774.8	40.6	1,209.9	448.1	761.8

2000-2020 Total: 1,062.4

Table S14 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
PLATTE-NIOBRARA SUBBASIN — 1965 TO 1980 PERIOD

Function	Plan Features With Initial Federal Investment ($ Millions)					Non-Federal Plan Features ($ Millions)		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						106.8		106.8
State & Local Recreation						166.9	104.8 1/	62.1
National Recreation Area								
Private Land Conservation						232.0	116.0	116.0
Irrigation Rehabilitation	32.2	32.2		32.2				
Access						2.6		2.6
Refuges	2.3	2.3						
Hatcheries	2.3	1.2			1.1			
Reservoirs						.6		.6
Water Control and Related Land								
Single Purpose F. C.	95.9	76.8			19.1			
Other Single Purpose Res.	147.2	147.2		147.2				
Grade Stabilization	.6	.5			.1			
Bank Stabilization	1.0	.7			.3			
M. P. Reservoirs	398.0	(165.0)	(233.0)	(203.7)				
Water Quality			12.0					
Irrigation			65.2	65.2				
M & I			45.8	45.8				
Power		17.0	44.2	61.2				
Recreation		59.0	32.9	29.5				
Fish and Wildlife		4.0	32.9	2.0				
Flood Control		85.0						
Surface Water Irrigation	177.3	177.3		177.3		26.8		26.8
Group Drainage	6.4	3.2			3.2			
Public Land Conservation	4.0	4.0						
Environ. and Non-Structural								
Sewage Treatment						71.0	21.3	49.7
Water Supply & Treatment						114.9	57.5	57.4
Fish and Wildlife								
Wetlands								
Management Areas						22.3	11.2	11.1
Fish Hatcheries	4.6	2.3			2.3			
Fish Impoundments	3.5	1.8			1.7			
Scenic Rivers								
Trails	.2	.2						
Flood Plain Management	.8	.8				51.1		51.1
Forest Management	.2	.2						
Precip. Management	1.8	1.8						
Totals	878.3	617.5	233.0	560.4	27.8	795.0	310.8	484.2

1965-1980 Total: 1,673.3

1/ Includes 63.3 million for recreation facilities on Federal lands which would be federally financed but whose costs would not be included under the grant program.

Table S15 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY PLATTE—NIOBRARA SUBBASIN — 1980 TO 2000 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						100.4		100.4
State & Local Recreation						114.9	66.5 1/	48.4
National Recreation Area								
Private Land Conservation						291.0	145.5	145.5
Irrigation Rehabilitation	53.0	53.0		53.0				
Access						4.2		4.2
Refuges								
Hatcheries								
Reservoirs						47.8		47.8
Water Control and Related Land								
Single Purpose F. C.	11.5	9.2			2.3			
Other Single Purpose Res.	205.0	205.0		205.0				
Grade Stabilization	1.3	1.0			.3			
Bank Stabilization	2.0	1.4			.6			
M. P. Reservoirs	491.0	(210.0)	(281.0)	(204.6)				
Water Quality			26.1					
Irrigation			61.5	61.5				
M & I			91.6	91.6				
Power								
Recreation		101.0	50.9	50.5				
Fish and Wildlife		2.0	50.9	1.0				
Flood Control		107.0						
Surface Water Irrigation	138.8	138.8		138.8		11.2		11.2
Group Drainage	3.3	1.7			1.6			
Public Land Conservation	6.0	6.0						
Environ. and Non-Structural								
Sewage Treatment						73.0	21.9	51.1
Water Supply & Treatment						165.6	82.8	82.8
Fish and Wildlife								
Wetlands								
Management Areas						.8	.4	.4
Fish Hatcheries								
Fish Impoundments								
Scenic Rivers	.7	.7						
Trails	3.2	3.2						
Flood Plain Management	.8	.8				83.3		83.3
Forest Management	.5	.5						
Precip. Management	3.8	3.8						
Incremental Totals	920.9	635.1	281.0	601.4	4.8	892.2	317.1	575.1
Cumulative Totals	1,799.2	1,252.6	514.0	1,161.8	32.6	1,687.2	627.9	1,059.3

1980-2000 Total: 1,813.1

1/ Includes $34.3 million for recreation facilities on Federal lands which would be federally financed but whose costs would not be included under the grant program.

Table S16 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
PLATTE-NIOBRARA SUBBASIN - 2000 TO 2020 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						139.2		139.2
State & Local Recreation						280.6	170.5 1/	110.1
National Recreation Area								
Private Land Conservation						316.0	158.0	158.0
Irrigation Rehabilitation	91.8	91.8		91.8				
Access						3.5		3.5
Refuges								
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	7.8	6.2			1.6			
Other Single Purpose Res.								
Grade Stabilization	2.2	1.8			.4			
Bank Stabilization	1.0	.7			.3			
M. P. Reservoirs	383.0	(258.5)	(124.5)	(222.8)				
Water Quality			10.3					
Irrigation			41.7	41.7				
M & I			27.1	27.1				
Power		70.0		70.0				
Recreation		167.0	22.7	83.5				
Fish and Wildlife		1.0	22.7	.5				
Flood Control		20.5						
Surface Water Irrigation	97.8	97.8		97.8		15.4		15.4
Group Drainage	5.3	2.7			2.6			
Public Land Conservation	7.5	7.5						
Environ. and Non-Structural								
Sewage Treatment						79.0	23.7	55.3
Water Supply & Treatment						179.2	89.6	89.6
Fish and Wildlife								
Wetlands								
Management Areas						.8	.4	.4
Fish Hatcheries								
Fish Impoundments	3.6	1.8			1.8			
Scenic Rivers								
Trails	1.8	1.8						
Flood Plain Management	1.0	1.0				52.1		52.1
Forest Management								
Precip. Management	9.7	9.7						
Incremental Totals	612.5	481.3	124.5	412.4	6.7	1,065.8	442.2	623.6
Cumulative Totals	2,411.7	1,733.9	638.5	1,574.2	39.3	2,753.0	1,070.1	1,682.9
				2000-2020 Total: 1,678.3				

1/ Includes $97.1 million for recreation facilities on Federal lands which would be federally financed but whose costs would not be included under the grant program.

Table S17 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
MIDDLE MISSOURI SUBBASIN — 1965 TO 1980 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)				
	Total	Specific	Joint	Repayable	Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						43.6		43.6
State & Local Recreation						39.9	16.0	23.9
National Recreation Area								
Private Land Conservation						77.0	38.5	38.5
Irrigation Rehabilitation								
Access						.9		.9
Refuges	2.4	2.4						
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	13.5	10.8			2.7			
Other Single Purpose Res.						42.1		42.1
Grade Stabilization	31.1	24.9			6.2			
Bank Stabilization	6.4	4.5			1.9			
M. P. Reservoirs	165.5	(117.3)	(48.2)	(25.9)				
Water Quality			9.8					
Irrigation			14.2	14.2				
M & I								
Power								
Recreation		45.5	12.1	11.7				
Fish and Wildlife			12.1					
Flood Control		71.8						
Surface Water Irrigation						4.2		4.2
Group Drainage	.2	.1			.1			
Public Land Conservation								
Environ. and Non-Structural								
Sewage Treatment						50.0	15.0	35.0
Water Supply & Treatment						74.6	37.3	37.3
Fish and Wildlife								
Wetlands								
Management Areas						17.6	8.8	8.8
Fish Hatcheries	1.2	.6			.6			
Fish Impoundments	.2	.1			.1			
Scenic Rivers								
Trails								
Flood Plain Management	.4	.4				18.0		18.0
Forest Management								
Precip. Management								
Totals	220.9	161.1	48.2	25.9	11.6	367.9	115.6	252.3

1965-1980 Total: 588.8

Table S18 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
MIDDLE MISSOURI SUBBASIN – 1980 TO 2000 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						107.2		107.2
State & Local Recreation						88.4	35.4	53.0
National Recreation Area								
Private Land Conservation						110.0	55.0	55.0
Irrigation Rehabilitation								
Access						.2		.2
Refuges								
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	30.4	24.3			6.1			
Other Single Purpose Res.						38.6		38.6
Grade Stabilization	49.8	39.8			10.0			
Bank Stabilization	12.9	9.0			3.9			
M. P. Reservoirs	119.3	(80.5)	(38.8)	(21.3)				
Water Quality			7.7					
Irrigation			13.3	13.3				
M & I								
Power								
Recreation		34.3	8.9	8.0				
Fish and Wildlife			8.9					
Flood Control		46.2						
Surface Water Irrigation						14.1		14.1
Group Drainage	1.8	.9			.9			
Public Land Conservation	.1	.1						
Environ. and Non-Structural								
Sewage Treatment						42.0	12.6	29.4
Water Supply & Treatment						75.4	37.7	37.7
Fish and Wildlife								
Wetlands								
Management Areas						7.7	3.9	3.8
Fish Hatcheries	1.2	.6			.6			
Fish Impoundments								
Scenic Rivers								
Trails	.8	.8						
Flood Plain Management	.9	.9				68.9		68.9
Forest Management								
Precip. Management								
Incremental Totals	217.2	156.9	38.8	21.3	21.3	552.5	144.6	407.9
Cumulative Totals	438.1	318.0	87.0	47.2	33.1	920.4	260.2	660.2

1980-2000 Total: 769.7

Table S19 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
MIDDLE MISSOURI SUBBASIN — 2000 TO 2020 PERIOD

Function	Plan Features With Initial Federal Investment: Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Non-Federal Plan Features: Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						105.6		105.6
State & Local Recreation						78.0	31.2	46.8
National Recreation Area								
Private Land Conservation						141.0	70.5	70.5
Irrigation Rehabilitation								
Access								
Refuges								
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	4.8	3.8			1.0			
Other Single Purpose Res.						54.9		54.9
Grade Stabilization	62.0	49.6			12.4			
Bank Stabilization	6.4	4.5			1.9			
M. P. Reservoirs	165.5	(122.9)	(42.6)	(29.5)				
Water Quality			7.7					
Irrigation			14.7	14.7				
M & I								
Power								
Recreation		66.5	10.1	14.8				
Fish and Wildlife			10.1					
Flood Control		56.4						
Surface Water Irrigation	20.6	20.6		20.6		46.2		46.2
Group Drainage	2.0	1.0			1.0			
Public Land Conservation								
Environ. and Non-Structural								
Sewage Treatment						39.0	11.7	27.3
Water Supply & Treatment						69.8	34.9	34.9
Fish and Wildlife								
Wetlands								
Management Areas								
Fish Hatcheries								
Fish Impoundments								
Scenic Rivers								
Trails	.8	.8						
Flood Plain Management	.7	.7				14.5		14.5
Forest Management								
Precip. Management								
Incremental Totals	262.8	203.9	42.6	50.1	16.3	549.0	148.3	400.7
Cumulative Totals	700.9	521.9	129.6	97.3	49.4	1,469.4	408.5	1,060.9

2000-2020 Total: 811.8

Table S20 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
KANSAS SUBBASIN – 1965 TO 1980 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						130.0		130.0
State & Local Recreation						103.7	41.5	62.2
National Recreation Area								
Private Land Conservation						182.0	91.0	91.0
Irrigation Rehabilitation								
Access						.1		.1
Refuges	.9	.9						
Hatcheries								
Reservoirs	3.3	3.3						
Water Control and Related Land								
Single Purpose F. C.	10.4	8.3			2.1			
Other Single Purpose Res.								
Grade Stabilization	8.8	7.0			1.8			
Bank Stabilization	2.4	1.7			.7			
M. P. Reservoirs	211.0	(153.0)	(58.0)	(26.3)				
Water Quality			10.6					
Irrigation			10.2	10.2				
M & I			14.6	14.6				
Power								
Recreation		3.0	11.3	1.5				
Fish and Wildlife			11.3					
Flood Control		150.0						
Surface Water Irrigation	41.1	41.1		41.1		2.6		2.6
Group Drainage	.7	.4			.3			
Public Land Conservation	.1	.1						
Environ. and Non-Structural								
Sewage Treatment						52.0	15.6	36.4
Water Supply & Treatment						106.6	53.3	53.3
Fish and Wildlife								
Wetlands	3.0	2.9			.1			
Management Areas						1.4	.7	.7
Fish Hatcheries	.6	.3			.3			
Fish Impoundments								
Scenic Rivers								
Trails	.5	.5						
Flood Plain Management	.2	.2				21.8		21.8
Forest Management								
Precip. Management								
Totals	283.0	219.7	58.0	67.4	5.3	600.2	202.1	398.1

1965-1980 Total: 883.2

Table S21 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY KANSAS SUBBASIN — 1980 TO 2000 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
				(Non-Federal)				
	Total	Specific	Allocated Joint	Repayable	Cost-Share	Total	Fed. Grants & Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						86.8		86.8
State & Local Recreation						103.2	41.3	61.9
National Recreation Area								
Private Land Conservation						250.0	125.0	125.0
Irrigation Rehabilitation	13.3	13.3		13.3				
Access						.1		.1
Refuges	.9	.9						
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	11.9	9.5			2.4			
Other Single Purpose Res.								
Grade Stabilization	.9	.7			.2			
Bank Stabilization	4.7	3.3			1.4			
M. P. Reservoirs	166.0	(123.0)	(43.0)	(22.7)				
Water Quality			6.9					
Irrigation			17.0	17.0				
M & I			3.7	3.7				
Power								
Recreation		4.0	7.7	2.0				
Fish and Wildlife			7.7					
Flood Control		119.0						
Surface Water Irrigation	548.3	548.3		548.3		5.4		5.4
Group Drainage	2.4	1.2			1.2			
Public Land Conservation	.2	.2						
Environ. and Non-Structural								
Sewage Treatment						58.0	17.4	40.6
Water Supply & Treatment						149.0	74.5	74.5
Fish and Wildlife								
Wetlands	2.9	2.7			.2			
Management Areas						3.0	1.5	1.5
Fish Hatcheries	.3	.2			.1			
Fish Impoundments								
Scenic Rivers								
Trails	.3	.3						
Flood Plain Management	.6	.6				38.2		38.2
Forest Management								
Precip. Management								
Incremental Totals	752.7	704.2	43.0	584.3	5.5	693.7	259.7	434.0
Cumulative Totals	1,035.7	923.9	101.0	651.7	10.8	1,293.9	461.8	832.1

1980-2000 Total: 1,446.4

Table S22 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY KANSAS SUBBASIN — 2000 TO 2020 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						162.8		162.8
State & Local Recreation						124.4	49.8	74.6
National Recreation Area								
Private Land Conservation						255.0	127.5	127.5
Irrigation Rehabilitation	13.0	13.0		13.0				
Access						.1		.1
Refuges	.9	.9						
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	2.5	2.0			.5			
Other Single Purpose Res.								
Grade Stabilization	2.3	1.9			.4			
Bank Stabilization	2.4	1.7			.7			
M. P. Reservoirs	144.0	(102.0)	(42.0)	(11.9)				
Water Quality			17.0					
Irrigation			9.4	9.4				
M & I								
Power								
Recreation		5.0	7.8	2.5				
Fish and Wildlife			7.8					
Flood Control		97.0						
Surface Water Irrigation	9.9	9.9		9.9		9.4		9.4
Group Drainage	.6	.3			.3			
Public Land Conservation	.1	.1						
Environ. and Non-Structural								
Sewage Treatment						65.0	19.5	45.5
Water Supply & Treatment						144.6	72.3	72.3
Fish and Wildlife								
Wetlands	4.3	4.0			.3			
Management Areas						3.6	1.8	1.8
Fish Hatcheries	.3	.2			.1			
Scenic Rivers								
Trails	.8	.8						
Flood Plain Management	.5	.5				47.8		47.8
Forest Management								
Precip. Management								
Incremental Totals	181.6	137.3	42.0	34.8	2.3	812.7	270.9	541.8
Cumulative Totals	1,217.3	1,061.2	143.0	686.5	13.1	2,106.6	732.7	1,373.9
				2000-2020 Total:	994.3			

Table S23 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY LOWER MISSOURI SUBBASIN — 1965 TO 1980 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						10.8		10.8
State & Local Recreation						115.0	46.0	69.0
Private Land Conservation						134.0	67.0	67.0
Irrigation Rehabilitation								
Access						3.4		3.4
Refuges								
Hatcheries								
Reservoirs	5.7	5.7						
Water Control and Related Land								
Single Purpose F. C.	219.5	175.6			43.9			
Other Single Purpose Res.								
Grade Stabilization	37.1	29.7			7.4			
Bank Stabilization	.4	.3			.1			
M. P. Reservoirs	522.0	(310.2)	(211.8)	(109.8)				
Water Quality			26.3					
Irrigation			15.2	15.2				
M & I			46.8	46.8				
Power		7.0	26.3	33.3				
Recreation		29.0	48.6	14.5				
Fish and Wildlife			48.6					
Flood Control		274.2						
Surface Water Irrigation						12.6		12.6
Group Drainage	2.0	1.0			1.0			
Public Land Conservation	.1	.1						
Environ. and Non-Structural								
Sewage Treatment						73.0	21.9	51.1
Water Supply & Treatment						115.0	57.5	57.5
Fish and Wildlife								
Wetlands								
Management Areas						17.3	8.7	8.6
Fish Hatcheries								
Fish Impoundments	2.3	1.2			1.1			
Scenic Rivers	.9	.9						
Trails								
Flood Plain Management	.3	.3				95.5		95.5
Forest Management								
Precip Management								
Totals	790.3	525.0	211.8	109.8	53.5	576.6	201.1	375.5
	1965-1980 Total: 1,366.9							

Table S24 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
LOWER MISSOURI SUBBASIN – 1980 TO 2000 PERIOD

	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
Function	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						15.8		15.8
State & Local Recreation						314.7	126.0	188.7
National Recreation Area								
Private Land Conservation						176.0	88.0	88.0
Irrigation Rehabilitation								
Access						.2		.2
Refuges								
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.	100.0	80.0			20.0			
Other Single Purpose Res.								
Grade Stabilization	19.4	15.5			3.9			
Bank Stabilization	.6	.4			.2			
M. P. Reservoirs	312.0	(164.5)	(147.5)	(26.6)				
Water Quality			11.2					
Irrigation			13.6	13.6				
M & I			7.5	7.5				
Power								
Recreation		11.0	57.6	5.5				
Fish and Wildlife			57.6					
Flood Control		153.5						
Surface Water Irrigation						19.5		19.5
Group Drainage	1.5	.8			.7			
Public Land Conservation	.2	.2						
Environ. and Non-Structural								
Sewage Treatment						82.0	24.6	57.4
Water Supply & Treatment						148.2	74.1	74.1
Fish and Wildlife								
Wetlands	2.5	2.4			.1			
Management Areas						3.9	2.0	1.9
Fish Hatcheries								
Fish Impoundments	3.3	1.7			1.6			
Scenic Rivers	5.0	5.0						
Trails	.8	.8						
Flood Plain Management	.8	.8				97.9		97.9
Forest Management								
Precip. Management								
Incremental Totals	446.1	272.1	147.5	26.6	26.5	858.2	314.7	543.5
Cumulative Totals	1,236.4	797.1	359.3	136.4	80.0	1,434.8	515.8	919.0

1980–2000 Total: 1,304.3

Table S25 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
LOWER MISSOURI SUBBASIN — 2000 TO 2020 PERIOD

Function	Plan Features With Initial Federal Investment: Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Non-Federal Plan Features: Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						14.6		14.6
State & Local Recreation						411.0	164.4	246.6
National Recreation Area								
Private Land Conservation						197.0	98.5	98.5
Irrigation Rehabilitation								
Access						.2		.2
Refuges								
Hatcheries								
Reservoirs								
Water Control and Related Land								
Single Purpose F. C.								
Other Single Purpose Res.								
Grade Stabilization	5.2	4.1			1.1			
Bank Stabilization	.4	.3			.1			
M. P. Reservoirs	62.0	(46.2)	(15.8)	(3.1)				
Water Quality			4.3					
Irrigation								
M & I			3.1	3.1				
Power								
Recreation			4.2					
Fish and Wildlife			4.2					
Flood Control		46.2						
Surface Water Irrigation						25.4		25.4
Group Drainage	1.5	.8			.7			
Public Land Conservation	.1	.1						
Environ. and Non-Structural								
Sewage Treatment						122.0	36.6	85.4
Water Supply & Treatment						135.9	68.0	67.9
Fish and Wildlife								
Wetlands								
Management Areas						2.9	1.5	1.4
Fish Hatcheries	5.0	2.5			2.5			
Fish Impoundments	3.0	1.5			1.5			
Scenic Rivers								
Trails								
Flood Plain Management	.3	.3				15.9		15.9
Forest Management								
Precip. Management								
Incremental Totals	77.5	55.8	15.8	3.1	5.9	924.9	369.0	555.9
Cumulative Totals	1,313.9	852.9	375.1	139.5	85.9	2,359.7	884.8	1,474.9

2000-2020 Total: 1,002.4

Table S26 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
MISSOURI BASIN – 1965 TO 1980 PERIOD

Function	Plan Features With Initial Federal Investment: Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Non-Federal Plan Features: Total	Fed. Grants & Assistance	Local
	($ Millions)					($ Millions)		
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						308.8		308.8
State & Local Recreation						683.6	311.3 1/	372.3
National Recreation Area	17.0	17.0						
Private Land Conservation						978.0	489.0	489.0
Irrigation Rehabilitation	62.5	62.5		62.5				
Access						10.0		10.0
Refuges	13.0	13.0						
Hatcheries	3.0	1.6			1.4			
Reservoirs	9.0	9.0				36.5		36.5
Water Control and Related Land								
Single Purpose F. C.	398.4	318.8			79.6			
Other Single Purpose Res.	154.1	154.1		147.2		46.6		46.6
Grade Stabilization	82.9	66.3			16.6			
Bank Stabilization	13.0	9.2			3.8			
M. P. Reservoirs	1,761.5	(947.9)	(813.6)	(634.7)				
Assoc. Joint Works	70.0		(70.0)	(68.5)				
Water Quality			79.5					
Irrigation			292.0	292.0				
M & I			121.4	121.4				
Power		112.0	92.1	204.1				
Recreation		189.5	148.6	83.7				
Fish and Wildlife		4.0	150.0	2.0				
Flood Control		642.4						
Surface Water Irrigation	392.1	392.1		392.1		194.6		194.6
Group Drainage	11.6	5.9			5.7			
Public Land Conservation	12.9	12.9						
Environ. and Non-Structural								
Sewage Treatment						335.0	100.5	234.5
Water Supply & Treatment						510.9	255.5	255.4
Fish and Wildlife								
Wetlands	59.6	56.6			3.0			
Management Areas						68.7	34.5	34.2
Fish Hatcheries	8.8	4.5			4.3			
Fish Impoundments	10.8	5.5			5.3			
Scenic Rivers	.9	.9						
Trails	21.6	21.6						
Flood Plain Management	2.2	2.2				204.0		204.0
Forest Management	.5	.5						
Precip. Management	4.0	4.0						
Totals	3,109.4	2,106.1	883.6	1,305.0	119.7	3,376.7	1,190.8	2,185.9

1965-1980 Total: 6,486.1

1/ Includes 63.3 million for recreation facilities on Federal lands which would be federally financed but whose costs would not be included under the grant program.

Table S27 — INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
MISSOURI BASIN — 1980 TO 2000 PERIOD

Function	Plan Features With Initial Federal Investment ($ Millions)					Non-Federal Plan Features ($ Millions)		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						348.0		348.0
State & Local Recreation						1,016.1	427.2	588.9
National Recreation Area	37.2	37.2						
Private Land Conservation						1,368.0	684.0	684.0
Irrigation Rehabilitation	111.5	111.5		111.5				
Access						8.7		8.7
Refuges	4.6	4.6						
Hatcheries	.7	.4			.3			
Reservoirs	10.5	10.5				48.3		48.3
Water Control and Related Land								
Single Purpose F. C.	163.8	131.0			32.8			
Other Single Purpose Res.	205.2	205.2		205.0		47.5		47.5
Grade Stabilization	75.6	60.4			15.2			
Bank Stabilization	25.8	18.0			7.8			
M. P. Reservoirs	1,477.3	(791.0)	(686.3)	(434.8)				
Assoc. Joint Works	177.0		(177.0)	(167.6)				
Water Quality			59.0					
Irrigation			373.7	373.7				
M & I			110.2	110.2				
Power								
Recreation		252.3	159.1	117.0				
Fish and Wildlife		3.0	160.7	1.5				
Flood Control		535.7	.6					
Surface Water Irrigation	893.8	893.8		893.8		205.1		205.1
Group Drainage	53.3	26.8			26.5			
Public Land Conservation	28.8	28.8						
Environ. and Non-Structural								
Sewage Treatment						345.0	103.5	241.5
Water Supply & Treatment						673.4	336.7	336.7
Fish and Wildlife								
Wetlands	7.1	6.7			.4			
Management Areas						23.5	11.9	11.6
Fish Hatcheries	1.5	.8			.7			
Fish Impoundments	4.5	2.3			2.2			
Scenic Rivers	10.3	10.3						
Trails	5.8	5.8						
Flood Plain Management	4.1	4.1				319.1		319.1
Forest Management	1.4	1.4						
Precip. Management	13.4	13.4						
Incremental Totals	3,313.2	2,364.0	863.3	1,812.7	85.9	4,447.7	1,563.3	2,884.4
Cumulative Totals	6,422.6	4,470.1	1,746.9	3,117.7	205.6	7,824.4	2,754.1	5,070.3
Missouri River	90.0	90.0		30.0				

1980-2000 Total: 7,850.9

Table S28 – INITIAL INVESTMENT COST DISTRIBUTION SUMMARY
MISSOURI BASIN – 2000 TO 2020 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
			Allocated	(Non-Federal)			Fed. Grants	
	Total	Specific	Joint	Repayable	Cost-Share	Total	& Assistance	Local
			($ Millions)				($ Millions)	
Specified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						480.0		480.0
State & Local Recreation						1,449.7	638.2	811.5
National Recreation Area								
Private Land Conservation						1,442.0	721.0	721.0
Irrigation Rehabilitation	139.0	139.0		139.0				
Access						8.4		8.4
Refuges	.9	.9						
Hatcheries								
Reservoirs						1.0		1.0
Water Control and Related Land								
Single Purpose F. C.	17.6	14.0			3.6			
Other Single Purpose Res.	7.0	7.0				70.7		70.7
Grade Stabilization	85.2	68.2			17.0			
Bank Stabilization	13.0	9.2			3.8			
M. P. Reservoirs	1,002.5	(652.4)	(350.1)	(377.2)				
Assoc. Joint Works	322.0		(322.0)	(313.8)				
Water Quality			43.6					
Irrigation			433.4	433.4				
M & I			49.3	49.3				
Power		70.0		70.0				
Recreation		312.5	71.1	137.8				
Fish and Wildlife		1.0	73.9	.5				
Flood Control		268.9	.8					
Surface Water Irrigation	406.1	406.1		406.1		295.0		295.0
Group Drainage	9.4	4.8			4.6			
Public Land Conservation	20.8	20.8						
Environ. and Non-Structural								
Sewage Treatment						425.0	127.5	297.5
Water Supply & Treatment						645.4	322.7	322.7
Fish and Wildlife								
Wetlands	7.3	6.9			.4			
Management Areas						16.8	8.5	8.3
Fish Hatcheries	6.6	3.4			3.2			
Fish Impoundments	7.8	3.9			3.9			
Scenic Rivers	1.3	1.3						
Trails	3.4	3.4						
Flood Plain Management	4.6	4.6				205.4		205.4
Forest Management	.6	.6						
Precip. Management	25.3	25.3						
Incremental Totals	2,080.4	1,371.8	672.1	1,236.1	36.5	5,039.4	1,817.9	3,221.5
Cumulative Totals	8,503.0	5,841.9	2,419.0	4,353.8	242.1	12,863.8	4,572.0	8,291.8
Missouri River	3,000.0	3,000.0						

2000-2020 Total: 10,119.8

Table S29 – EXAMPLE OF MULTI-PURPOSE RESERVOIR COST ALLOCATION
KANSAS SUBBASIN – 1965 TO 1980 PERIOD

1. The storage cost is determined by subtracting the specific costs for facilities from the total reservoir costs.

Total cost:	$211 million
-Specific cost (recreation):	$ 3 million
=Storage cost:	$208 million

2. All storage, except for sediment and flood control, is considered joint storage even though there is specific storage for irrigation and M & I (recreation and fish and wildlife also use it).

Item	Storage (1,000 AF)	Percent of Total	Pro-rated Cost ($ Millions)
Sediment	322	14%	29
Flood Control	1,610	70%	145
Live Storage (joint)	372	16%	34
Total	2,304	100%	208

3. The joint costs are then pro-rated among the functions according to the percentage of storage and the sediment costs are shared equally by all functions.

Function	Storage (1,000 AF)	Share (%)	Pro-rated Cost ($M)	Sediment Cost ($M)	Specific Cost ($M)	Total Cost ($M)	Total Cost (%)
Quality	86	17	5.8	4.8		10.6	5
Irrigation	77	16	5.4	4.8		10.2	5
M & I	143	29	9.8	4.8		14.6	7
Power	0	0	0	0		0	0
Recreation 1/	93	19	6.5	4.8	3.0	14.3	7
Fish & Wildlife 1/	93	19	6.5	4.8		11.3	5
	492	100	34.0				
Flood Control			145.0	5.0		150.0	71
			Totals	29.0		211.0	100

1/ Allocation of 1/4 live storage to both recreation and fish and wildlife based on the assumption that the average pool would be about half-full.

Note: See the first three columns under multi-purpose reservoirs in Table S20 for comparison

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30 – SUMMARY OF INITIAL INVESTMENTS AND ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENT COSTS

1980		2000			2020		
Estimated Annual O, M & R ($ Million)	Average O, M & R Rate (Percent)	First Cost ($ Million)	Estimated Annual O, M & R ($ Million)	Average O, M & R Rate (Percent)	First Cost ($ Million)	Estimated Annual O, M & R ($ Million)	Average O, M & R Rate (Percent)
9	1.3	1,319	19	1.4	1,917	32	1.7
6	1.4	1,201	15	1.2	1,871	23	1.2
8	2.5	771	17	2.2	1,160	28	2.4
12	2.4	1,258	31	2.5	2,365	55	2.3
45	2.7	3,487	84	2.4	5,165	133	2.6
18	3.2	1,318	43	3.3	2,093	74	3.5
26	2.9	2,330	56	2.4	3,324	95	2.9
28	2.1	2,671	58	2.2	3,669	103	2.8
152	2.4	14,355	323	2.3	21,564	543	2.5

ble S31 – ANNUAL OPERATION, MAINTENANCE, AND REPLACEMENT COST DISTRIBUTION SUMMARY
MISSOURI BASIN – 1965 TO 2020 PERIOD

Function	Plan Features With Initial Federal Investment					Non-Federal Plan Features		
	Total	Specific	Allocated Joint	(Non-Federal) Repayable	(Non-Federal) Cost-Share	Total	Fed. Grants & Assistance	Local
	($ Thousands)					($ Thousands)		
pecified Non-Fed. and Mods.								
Pvt. Grd. Water Irrigation						95,167		95,167
State & Local Recreation						60,790		60,790
National Recreation Area	760	760						
Private Land Conservation						115,600		115,600
Irrigation Rehabilitation	1,492				1,492			
Access						1,446		1,446
Refuges	161	161						
Hatcheries	131				131			
Reservoirs	354	106			248	705		705
ater Control and Related Land								
Single Pu.pose F. C.	2,968				2,968			
Other Single Purpose Res.	1,316				1,316	1,047		1,047
Grade Stabilization	1,055				1,055			
Bank Stabilization	518				518			
M. P. Reservoirs	48,616	(41,301)	(7,315)	(41,385)				
Water Quality			759					
Irrigation		4,694	2,621	7,315				
M & I			758	758				
Power		2,250	308	2,558				
Recreation		27,809	1,436	29,245				
Fish and Wildlife		76	1,433	1,509				
Flood Control		6,472						
Surface Water Irrigation	7,552				7,552	3,300		3,300
Group Drainage	957				957			
Public Land Conservation	1,148	1,148						
nviron. and Non-Structural								
Sewage Treatment						68,699		68,699
Water Supply & Treatment						110,891		110,891
Fish and Wildlife								
Wetlands	251	251						
Management Areas						11,668		11,668
Fish Hatcheries	321				321			
Fish Impoundments	205				205			
Scenic Rivers	182				182			
Trails	308				308			
Flood Plain Management	193	193				3,638		3,638
Forest Management	25	25						
Precip. Management	—	—	—	—	—	—	—	—
otals	68,513	43,945	7,315	41,385	17,253	472,951		472,951

1965-2020 Total: 541,464